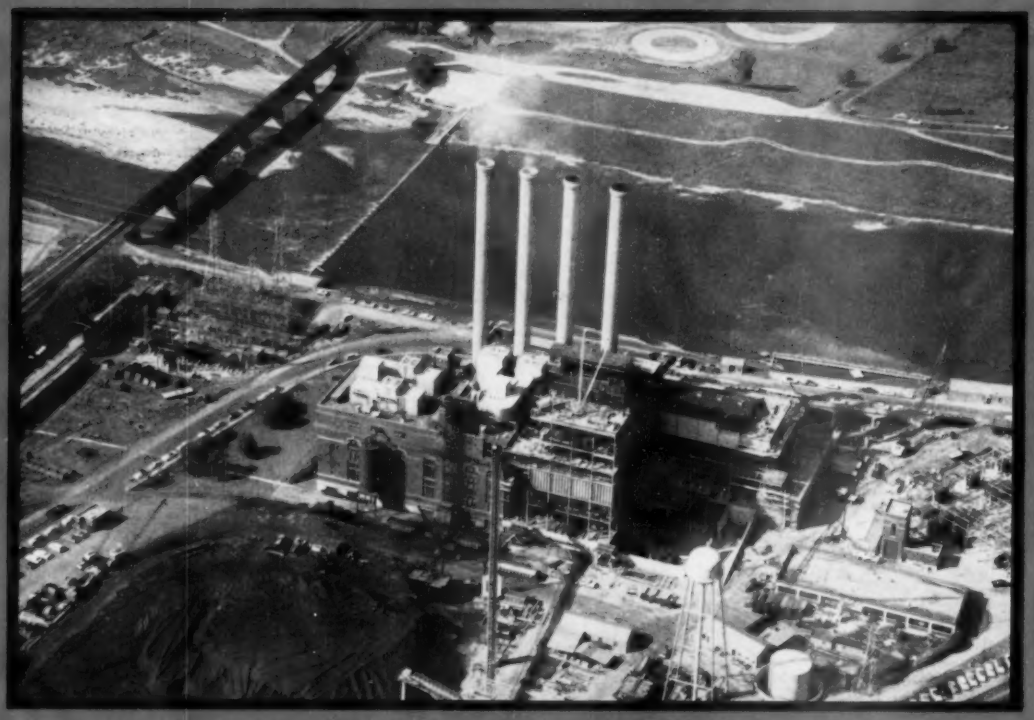
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

February 1958



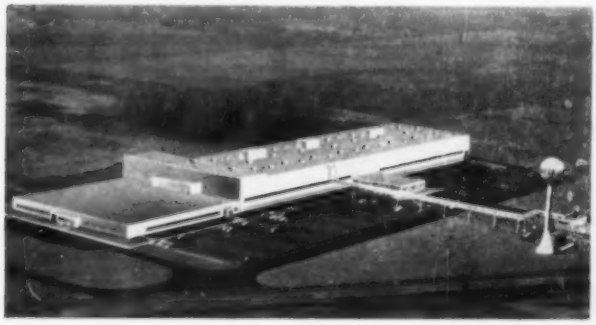
Construction view of the Frank M. Tait Station addition for The Dayton Power & Light Co. housing the new C-E Sulzer Monotube boiler

Combustion Control, Load Control Tie-ins

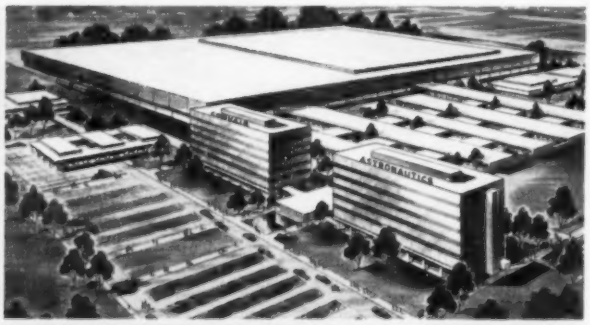
High Pressure Valves

Jet Cleaning Preheaters

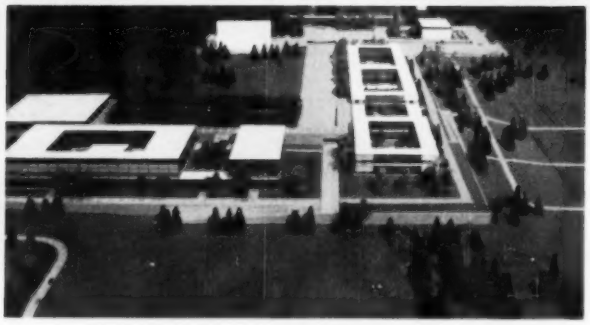
THE CROSS COMPANY—Fraser, Michigan
This automation equipment producer's new plant has two 12-million btu C-E Hot Water Boilers.



CONVAIR-ASTRONAUTICS—San Diego, California
New Convair space-flight research center will have two 30-million btu C-E Hot Water Boilers.



RIVERVIEW COMMUNITY HIGH SCHOOL—Riverview, Mich.
Two 10-million btu C-E Hot Water Boilers heat Riverview's recently expanded high school.



U.S. AIR FORCE ACADEMY—Colorado Springs, Colorado
Choice of five C-E units here typifies widespread Air Force acceptance of high temperature hot water.

HIGH TEMPERATURE WATER

today's new idea in large space heating

In such diverse applications as industrials, large educational institutions, and military bases, high temperature water is finding rapidly increasing acceptance as an ideal means of heating large areas.

A big factor in bringing this trend about is The C-E La Mont Controlled Circulation Hot Water Boiler. Using the same principle as that applied by C-E in many of the country's largest utility boilers, this new boiler provides a degree of temperature control that makes it the most attractive method of heating in many cases. With a wide range of capacities—from 10 to 300 million Btu's—these boilers operate at water pressures up to 500 psi and temperatures to 470F, or higher. A C-E Hot Water Boiler can save from 10 to 20 per cent in maintenance and operating costs.

Combustion Hot Water Boilers in the smaller capacity range are completely assembled in the shop while the intermediate and large units are shipped in varying stages of assembly. This C-E practice greatly reduces erection costs.

So, if you are in the market for boilers, either for space heating or process requirements, it may prove greatly to your advantage to investigate the use of high temperature water as your heat source. Because individual needs vary, both steam and hot water have their place. Our engineers will be pleased to discuss either method with you or your consultants—impartially and with no obligation.

For further details on high temperature water boilers by C-E write for our catalog HCC-2.

COMBUSTION ENGINEERING

Combustion Engineering Building, 200 Madison Avenue, New York 16, N.Y.
CANADA: COMBUSTION ENGINEERING-SUPERHEATER LTD.

C-120-A

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 29 **No. 8**

February 1958

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BPA

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POWER PIPING FIRSTS

that have made Kellogg the pacemaker

As steam turbine operating pressures and temperatures have increased over the past 25 years, The M. W. Kellogg Company has continued to set the pace in power piping design, fabrication, and erection. Many of the developments which have brought the central power station to its present efficiency may be traced to the laboratory or shop techniques developed or first put to use in the industry by Kellogg.

Among Kellogg's many "firsts" of a general nature, listed in chronological order, are:

- *Forge and hammer welding of intermediate joints and branch connections in the United States*
- *Bare wire electrode welding in the shop*
- *Coated electrode welding in the shop*
- *Shop-corrugated super-flexible pipe*
- *Streamlined forged fittings*
- *Development of an integrated analytical solution for piping flexibility analysis to include multiple anchor and intermediate restraint problems*
- *Use of inversion procedures for piping flexibility analysis*
- *Development of model testing method for solving piping flexibility procedures*
- *Evaluation of stress range concept and fatigue basis for flexibility design*
- *Development of material specifications for C. ½% Mo. pipe having #3-#5 actual grain size to give optimum strength at high temperatures*
- *Kelcaloy bi-metallic transition or "K" pieces to join ferritic to austenitic piping*

Kellogg's "firsts" in the fabrication of power piping, listed at the right, are even more numerous. Kellogg welcomes the opportunity to discuss its complete facilities with consulting engineers, engineers of power generating companies, and manufacturers of boilers, turbines, and allied equipment.

FABRICATED PRODUCTS DIVISION

The M. W. Kellogg Company

711 THIRD AVENUE, NEW YORK 17, N. Y.

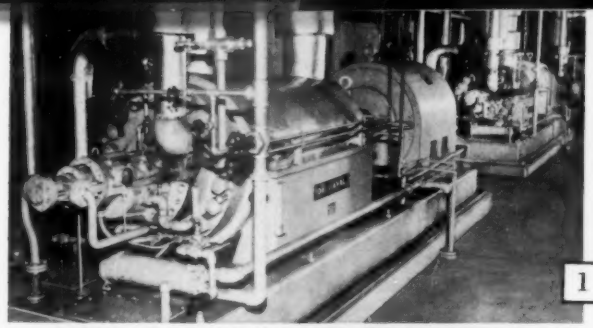
A SUBSIDIARY OF PULLMAN INCORPORATED

The Canadian Kellogg Co. Ltd., Toronto • Kellogg International Corp., London
Kellogg Pan American Corp., New York • Societe Kellogg, Paris • Companhia Kellogg Brasileira, Rio de Janeiro • Compania Kellogg de Venezuela, Caracas

FIRST IN FABRICATION OF:

- Piping from C. ½% Mo.
- Station piping for 900 F.
- Station piping for 950 F.
- Station piping for 2200 psi.
- C. ½% Mo. piping with #3-#5 actual grain size
- 1¼% Cr.-½% Mo. steam piping
- Steam piping for 1000 F.
- ½% Cr.-½% Mo. station piping
- 2% Cr.-½% Mo. station piping
- Station piping for 1000 F.
- 2¼% Cr.-1% Mo. station piping
- 1¼% Cr.-½% Mo. station piping
- 1% Cr.-1% Mo. V. turbine piping
- 2¼% Cr.-1% Mo. V. station piping
- Station piping for 1050 F.
- 3% Cr.-1% Mo. station piping
- Type 347 stainless turbine piping
- Mercury vapor piping for 1000 F.
- Station piping for 1003 F. for France
- Type 347 stainless station piping
- Station piping for 1100 F.
- Type 316 stainless station piping
- Type 316 stainless station piping for 3500 psi-1050 F., 325 MW.
- Type 316 stainless station piping for 5600 psi-1200 F., 325 MW.

POWER PIPING—THE VITAL LINK



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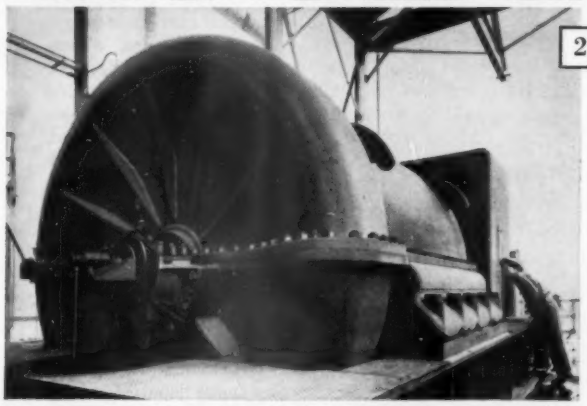

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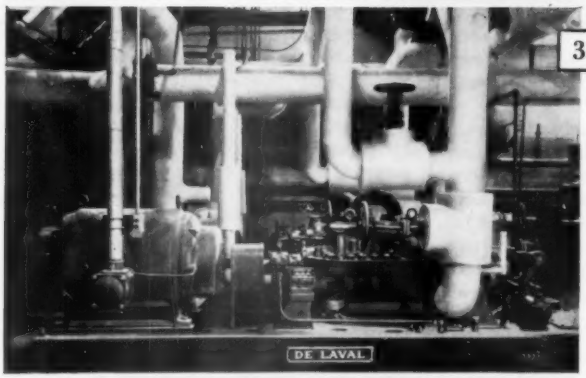

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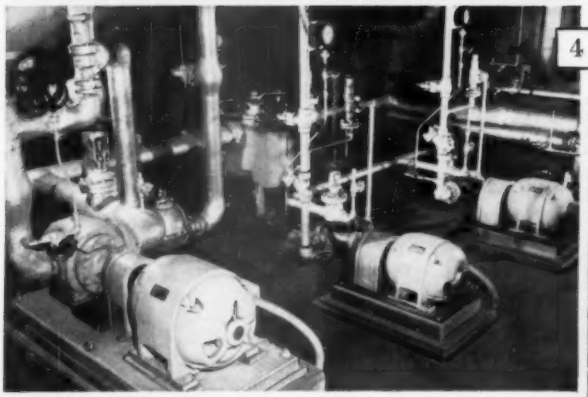

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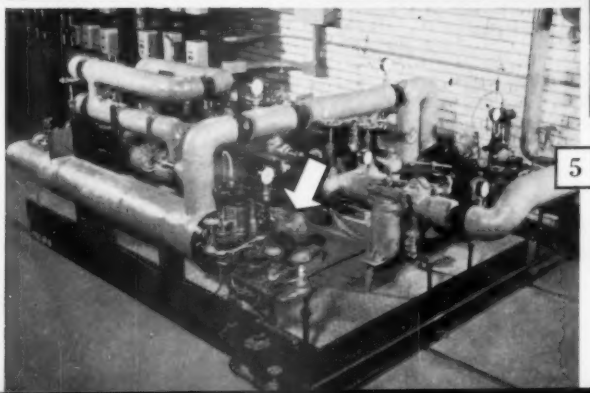


5

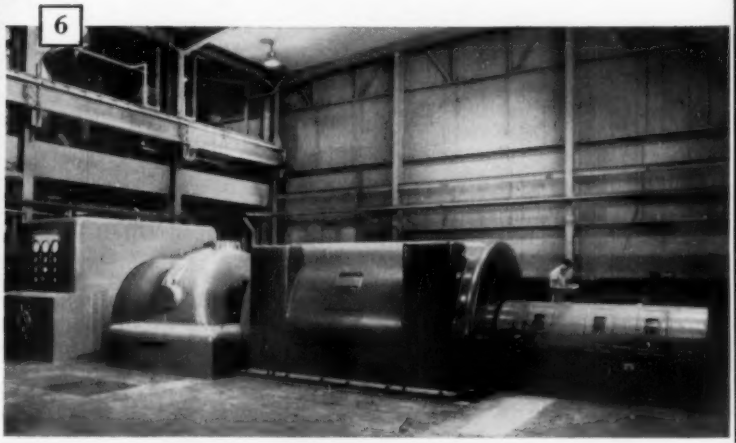
DE LAVAL

designs for dependability

Machines that *stay* in service year in and year out are the most economical. Since 1901, De Laval has supplied quality-designed pumps, compressors, and other vital equipment for industry. Each unit is designed for dependability and built by master craftsmen. As a result, the De Laval name plate is your assurance of reliability. Literature is available on all equipment shown on these pages.

1. Barrel type boiler feed pumps
2. Centrifugal compressors
3. Centrifugal pumps for many services
4. De Laval IMO pumps for fuel oil transfer
5. De Laval IMO pumps for fuel oil burner service
6. Multi-stage turbine generators

6



DE LAVAL

Steam Turbine Company

886 Nottingham Way, Trenton 2, New Jersey

DL-401

Hall Industrial Water Report

VOLUME 6 FEBRUARY 1958 NUMBER 1

By No Stretch of the Imagination

—can one think of getting along in the rubber industry without lots of water. And all the water used for generating steam, cooling, or general service must be conditioned to avoid problems such as deposit formation and corrosion. Undisciplined water can increase costs, hamper production and even shut down the plant. Contaminated waste water must also be cleaned up for disposal.

Hall Engineers are presently working with more than 80 plants in the rubber industry to avoid problems related to water. Whatever your industry, they can help you, too, with their special training and experience in the treatment of boiler water, cooling water, service water and process and waste water.

Careful Control Pays Off

In 1950 Hall staff engineer Len Highley set up the water conditioning procedures for two new boilers to provide steam at 550 psig in an eastern tire plant. Since then operation has been uneventful except for a short period of difficulty with hot-process softener filters and a temporary scare due to soap contamination of condensate. Because of these two events the boilers were acid washed as a precautionary measure early in 1956.

A recent report to Highley reads "We are sorry you were not able to get down to go over our No. 1 boiler, but we thought you would like to know that it was in the same clean condition as No. 2 which you inspected. Our operating people were very pleased and they have noted nothing to cause any concern or question."

This case might be considered just a routine report if we did not "look behind the scenes." There we find the close cooperation between the Hall engineer who prescribes water treating procedures on the basis of his study of the plant and the plant operating men who faithfully and carefully do the important job of maintaining day by day the water conditions which spell success.

Quick Diagnosis

When he collected a sample of the effluent from the hot lime-soda softener at a western tire plant, Hall Engineer John Henricks was surprised to find a noticeable amount of suspended matter in the water. This was unusual because, even though the softened water was not filtered, it had always been remarkably free from precipitated hardness which settled out in the sedimentation tank.

Investigation promptly disclosed that numerous new tire machines had boosted the load on the boilers and softener beyond rated capacities. The increased flow rate had to be maintained, but something had to be done to clean up the treated water to avoid increased chemical consumption in the boilers and abnormal sludge concentration in the boiler water.

Reasoning that a denser and deeper sludge blanket was needed in the softener tank to "filter" the suspended matter from the treated water, Henricks recommended reducing the blow-off from the tank and raising the level of the sludge blanket 6 to 12 inches. With these changes made, the softener water again was clear. But now there was another problem. The hardness of the water was running 0.5 gpg higher than normal. Henricks traced this to inaccurate weighing of treating chemicals and adjustment of slurry level in softener chemical tanks. With careful weighing of chemicals and preparation of slurry, hardness of the treated water ran consistently low at 0.2 to 0.3 gpg.

This is a case where the experience and training of the Hall Engineer enabled him quickly not only to spot trouble in the making but to diagnose the problems and solve them before they caused real trouble.

How to Fool a Deaerator

On his first service visit to a rubber reclaiming plant the Hall field engineer found an arrangement which topped all of his unusual experiences. Chemicals for the low-pressure boiler were fed continuously from two pressure pots with cold zeolite-treated water. The effluent from one pot entered the makeup water line to the deaerator downstream from the flow control valve. The effluent from the other entered the boiler feed line downstream from the deaerator.

Approximately 2000 gpd of water passed through each feeder. At low loads, when no makeup water was required, the cold water flowing into the deaerator from both feeders merely overflowed to the sewer. This also upset heater operation so when the load picked up undeaerated water was pumped to the boiler. The cold, undeaerated makeup water flowing into the boiler feed line continuously introduced dissolved oxygen into the boiler. Finally, at relatively low loads condensate entering the deaerating heater overflowed to the sewer.

By making a few simple piping changes so one feeder could be used intermittently to feed all chemicals, the Hall engineer was able to reduce makeup water consumption from 6000 gpd to 2000 gpd, to cut chemical feed by 75% and to insure satisfactory deaerator operation.

Industrial Water Problems Require Special Handling

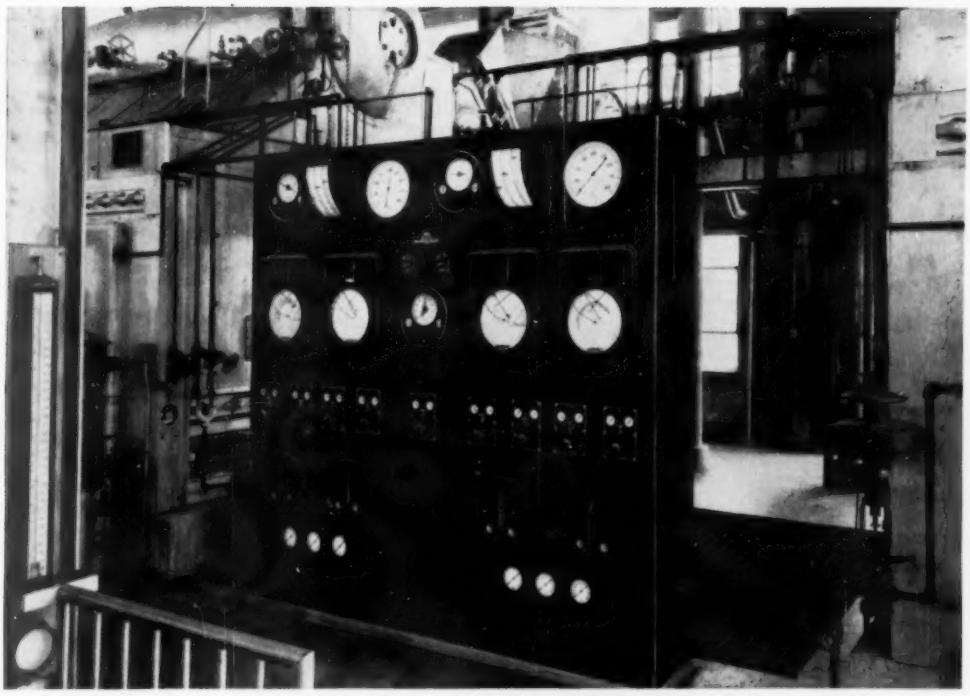
There are no "stock answers" to industrial water problems. For information on how the Hall System can help you solve your particular water problems, write, wire or call address below.

Water is your industry's most important raw material. Use it wisely.

HALL LABORATORIES

DIVISION OF HAGAN CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY; HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED - TORONTO

Hall Laboratories—Consultants on Procurement, Treatment, Use and Disposal of Industrial Water



Bailey Meters and Controls for two boilers in a midwestern milling company.

How Bailey helps you get a new boiler off to a fast, safe start——

--The thrill of putting a new boiler "on-the-line" can be marred if you lack adequate metering and control equipment. You are a lot surer of a fast, safe start and dependable operation for a long time when you specify Bailey Meters and Controls. They are keys to peak efficiency and low operating costs.

Bailey is the choice of virtually all the most efficient plants on the Federal Power Commission's heat rate report. Here's why:

1. A Complete Line of Equipment

You can be sure a Bailey Engineer will offer the right combination of equipment to fit your needs. Bailey manufactures a complete line of standard, compatible pneumatic and electric metering and control equipment that has proved itself. Thousands of successful installations involving problems in measurement, combustion, and automatic control are your assurance of the best possible system.

2. Experience

Bailey Engineers have been making steam plants work more efficiently for more than forty years. Veteran engineer and young engineer alike, the men who represent Bailey, are storehouses of knowledge on measurement and control. They are up-to-the-minute on the latest developments that can be applied to your problem.

3. Sales and Service Convenient to You

There's a Bailey District Office or Resident Engineer close to you. Check your phone book for expert engineering counsel on your steam plant control problems.

A131-1

BAILEY METERS

Instruments and controls for power and process

BAILEY METER COMPANY

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In Canada—Bailey Meter Company Limited, Montreal

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MANUFACTURERS OF BAYER SOOT BLOWERS

For Highest First and Final Value

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BAYER

Balanced Valve

SOOT CLEANER

Bayer's single-chain design compels perfect in-step operation of valve and element. Operation is positive, definite, assuring a full flow of steam for efficient cleaning.

When the operator pulls chain, the cam-actuated, quick-action balanced valve is opened. By continued pulling of the chain, worm drive slowly rotates element over cleaning arc. When element reaches end of cleaning arc, valve automatically closes.

Minimum steam consumption—low maintenance. Every detail is engineered, built for long life, efficient performance at high temperatures and high pressures.

More than 30,000 boilers are Bayer equipped. More than 45 years' successful, specialized experience assures you investment economies in Bayer equipment.

QUALIFIED LOCAL ENGINEERING SERVICE—Your Bayer representative is an experienced engineer, well qualified to take care of any service needs in connection with Bayer Soot Cleaners. He is available when you call upon him and will gladly render any service required.

All These Mechanical and Operating Advantages are available in

The BAYER

Balanced Valve

SOOT CLEANER

1. **Sound engineering, workmanship, and materials of the best.**
2. **An organization of over 45 years' experience, capable and willing to render service at all times.**

SINGLE CHAIN: Valve and element controlled by a single chain.

VALVE BODY: Rugged construction, built to last. Short and ample steam passage giving very small pressure drop.

ORIFICE PLATE VALVE: For high pressure service, each head may be controlled by an orifice plate valve through which pressure is adjusted for each individual element.

STUFFING BOX: Due to maintenance of perfect alignment on swivel tube, packing needs little attention. Stuffing box is in full view, readily accessible.

AIR SEAL: Has machined surface on wall sleeve and spring-held floating seal to prevent air in-leakage.

HEAD BEARINGS: There are two main bearings, an outboard and an inboard bearing for the swivel tube to maintain alignment.

THRUST BEARING: Ring type thrust bearing takes the load.

VACUUM BREAKERS: Two vacuum breaker air valves, or one valve and a signal whistle above each valve, to prevent suction of boiler gases into valve and piping.

ELEMENT OPERATION: With the Bayer element operation, balanced valve is opened just as element rotates, giving FULL pressure over entire cleaning arc. Full steam pressure insures thorough cleaning. Balanced valve saves wear of valve parts. With any type of poppet valve, this is important. . . ask any operator.

BLOWING ARC: Valve cams automatically regulate cleaning arc.

REDUCTION GEARS: 24 to 1 gear ratio gives slow rotation for good cleaning.

FLANGED PIPE CONNECTION: Operating head is connected to supply pipe by flanges and through bolts, or high tensile studs and nuts.

THE BAYER CO.

St. Louis, Mo.

COLOR-PORT

water level gage

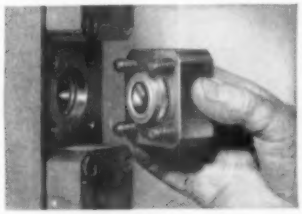
gives you . . . two-color readings
. . . low maintenance
. . . increased availability

You get a *triple advantage* with the Yarway COLOR-PORT boiler water level gage for pressures to 3000 psi.

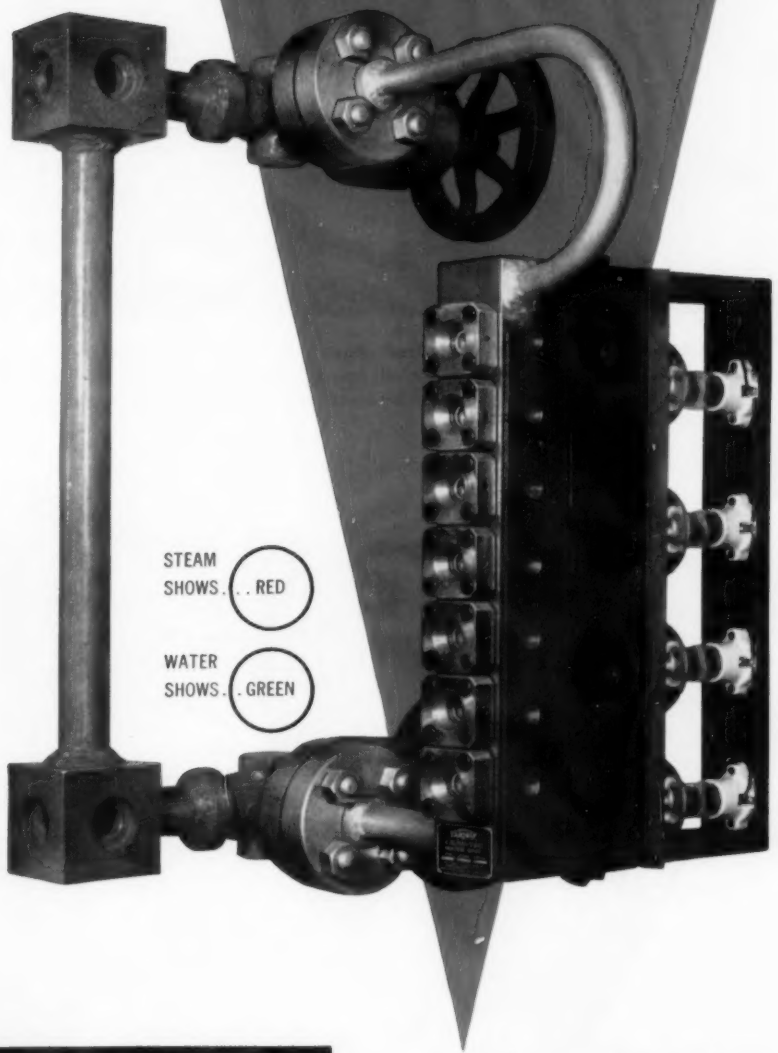
Two-color readings are brilliant and clear. Water shows green; steam shows red. A full gage is all green and an empty gage all red.

Low maintenance with individual cover-glass assemblies, each held solidly in place by four socket head cap screws. "Floating assembly" design applies safe, predetermined loads on glass ports, reducing thermal shocks, permitting faster warm-up.

Increased availability means longer service life. Cover glass assemblies can be *serviced in place*, easily and quickly.



Yarway Bulletin WG-1814 describes the Color-Port Gage. Write for it.

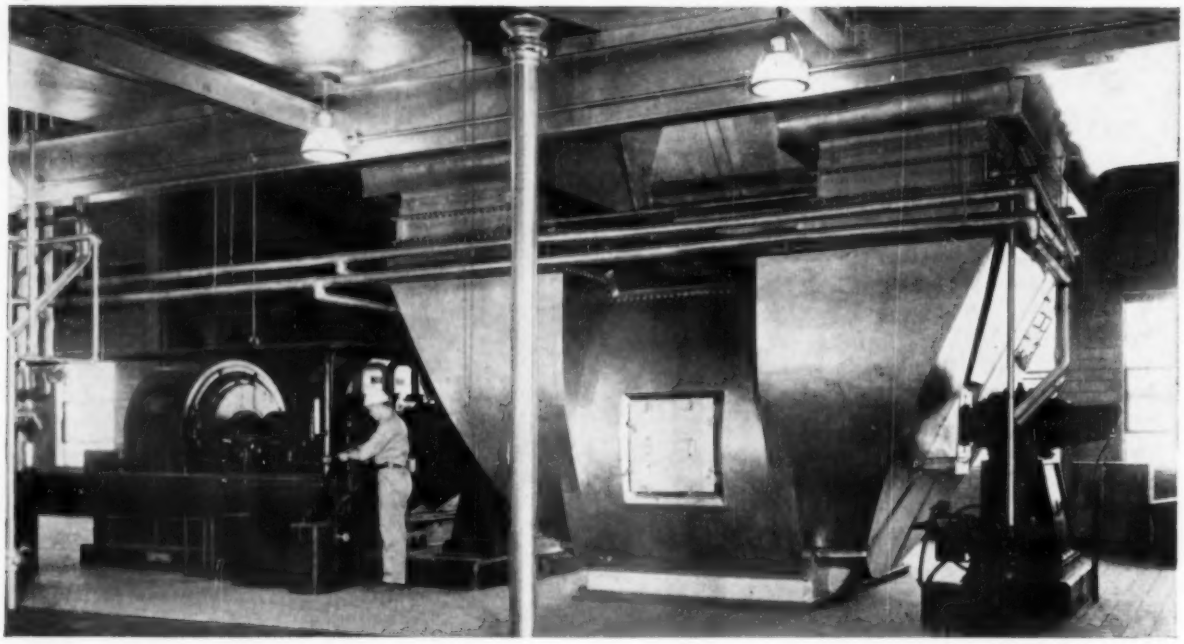


YARNALL-WARING COMPANY
100 Mermaid Avenue
Philadelphia 18, Pa.
Branch Offices in Principal Cities

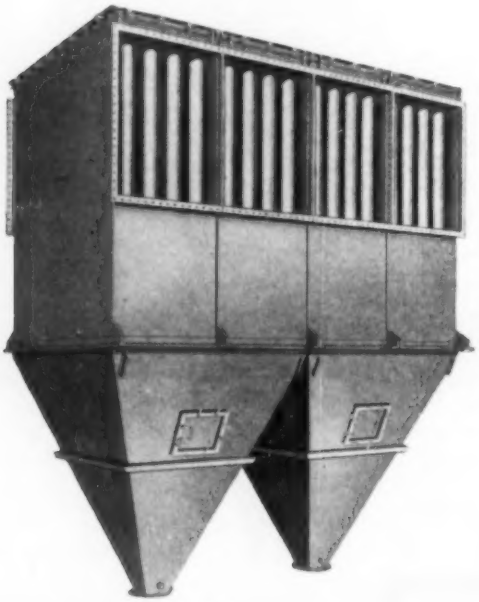
YARWAY COLOR-PORT . . . *a good way to specify high pressure water gages*

American Blower Air-Handling Equipment

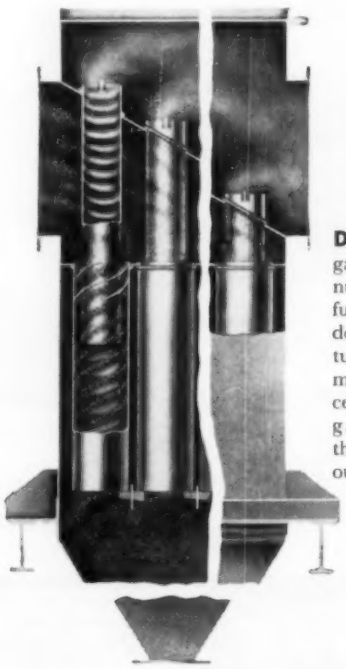
Proved efficiency



American Blower Induced-Draft Fans offer high static efficiency at low rpm. Like all American Blower mechanical-draft equipment, they are accurately formed and welded; fan rotors carefully balanced; all parts are minutely inspected for dimensional accuracy. They require a minimum space and minimum maintenance.



Series 342 Precipitator is easy to install and very effective in controlling fly ash. The over-all performance of each tube is comparable to the high efficiency of a small-diameter cyclone.



Dust-laden air or gas enters inlet plenum; gravity and centrifugal action force dust downward, adjacent to tube wall; dust is skimmed into gas-tight receptacle; cleaned air or gas moves upward through outlet tubes to outlet plenum.

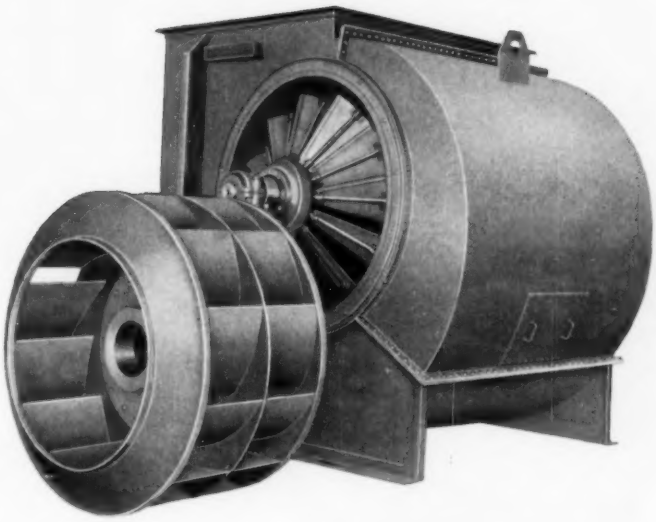
. . . maximum performance!

American Blower Mechanical Draft Fans

To meet the peak efficiency demanded of mechanical-draft equipment today, you'll be better off if you select spacesaving and efficient American Blower Mechanical Draft Fans.

Combining modern manufacturing methods with perpetual research and development, American Blower produces complete fan equipment for all types of mechanical draft. These induced-draft or forced-draft fans will fit your exact specifications with minimum maintenance and minimum boiler "outage."

If you are investigating mechanical-draft equipment—for new or existing installations—you'll do well to check on American Blower's line of Mechanical Draft Fans with guaranteed performance ratings. We welcome the opportunity of quoting on your requirements.



Forced Draft Fans for quiet indoor or outdoor installations. Heavy, reinforced housings and wheel-shaft assembly mean longer life, while special streamline inlets give utmost efficiency.

American Blower Precipitators

For maximum collection efficiency, choose the *best*—a dependable American Blower Precipitator!

Your fly ash problems can be met by installing a Series 342 Fly Ash Precipitator which offers good efficiency over the normal operating range, while it gives reliable, trouble-free performance.

American Blower's line of Fly Ash Precipitators and Dust Collectors has gained wide acceptance in leading public utilities and industrial plants.

For complete information on American Blower Dust Collectors and Precipitators as well as other air handling products, call our nearest branch, or write direct. American Blower Division of American-Standard, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ont.

AMERICAN BLOWER

Division of AMERICAN-Standard

QUALITY PROTECTS YOUR INVESTMENT . . . AMERICAN-Standard QUALITY IS AVAILABLE AT NO EXTRA COST

STOCK

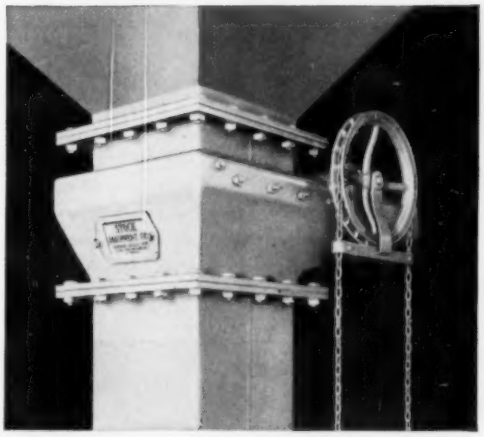
Dramatic "upside down" test tells

The inside story on the S-E-CO Coal Valve...

The simple test illustrated here proves graphically that the S-E-CO Coal Valve works under almost any kind of condition—even while it's standing on its head.

One reason for the superiority of the S-E-CO Valve is the exclusive self-cleaning design of the racks and pinions. Double pinions on either side of the gate project *through* the ladder racks, because the root portions of the racks have been eliminated. There is no place for coal to build up and cause jamming or cocking. This self-cleaning design helps the S-E-CO Valve operate smoothly and easily, even after long periods of infrequent use.

There are many other features that help to make the S-E-CO Coal Valve your best valve buy. Just one word of caution. Be sure to install *your* S-E-CO Valve right side up. It works even better that way.



BUILDING THE STANDING COLUMN

Valve is inverted and filled with coal. In this position racks and pinions are exposed. Normally an extra deep U-shaped gate protects them from contamination by coal particles.

PACKING THE COAL AGAINST PINIONS

2 x 4 is used to spread coal through valve and pack it against pinions (see opposite page). Don't forget, the valve gate must force its way through the coal that already fills the valve.

EVEN UPSIDE DOWN... IT CLOSES!

Here's proof that S-E-CO racks and pinions are *truly* self-cleaning. Valve gate closes, completely. And it opens again, all the way. If it works under these conditions, it will work even better for you.

Get the rest of the inside story on the S-E-CO Coal Valve. Send now for Bulletin 97.

Equipment Company

745-P HANNA BLDG. • CLEVELAND 15, OHIO

IMPROVED BLOWER NOZZLE and

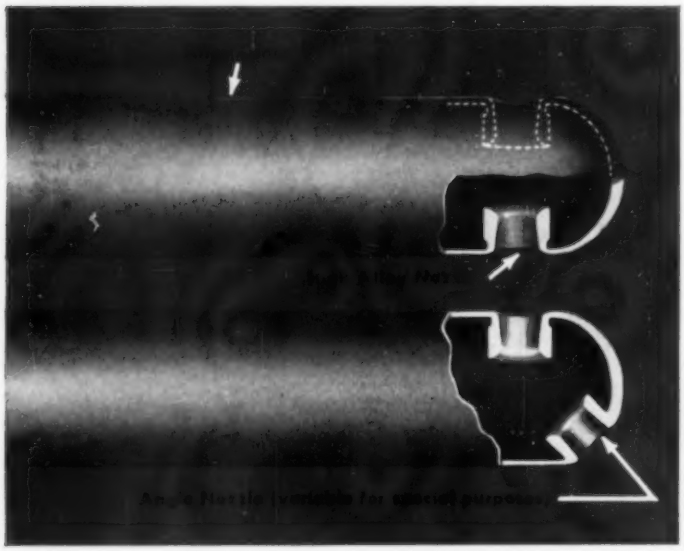
more important features of the

New Diamond Series 300 IK
LONG RETRACTING BLOWER

This improved nozzle provides more available cleaning energy per pound of steam or compressed air. A modified venturi, it is the result of extensive research during which more than 50 contours were tested.

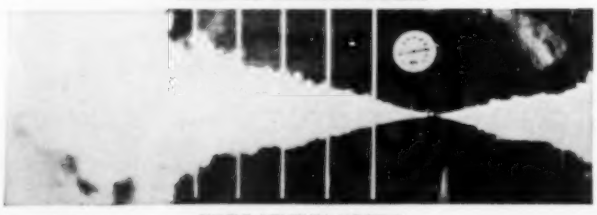
The positively-controlled, close helical cleaning pattern assures optimum coverage of the heating surface. Return travel path is exactly intermediate to forward travel path . . . resulting in a positive nozzle sweep every inch.

These features are two of many reasons why the Diamond Series 300 IK Blower does a better and more economical job of cleaning surfaces which require a long retracting blower. Other advantages are listed at the bottom of the opposite page. Ask the nearest Diamond office for Bulletin 2111V which will tell you much more about the new Series 300 IK.

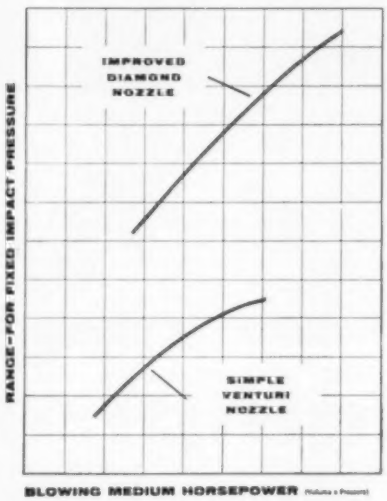


Improved Diamond Type "A" Nozzle has low approach velocity for optimum nozzle performance (see curves below). It provides greatest impact for any given blowing pressure . . . means greater effectiveness and economy.

IMPROVED DIAMOND NOZZLE

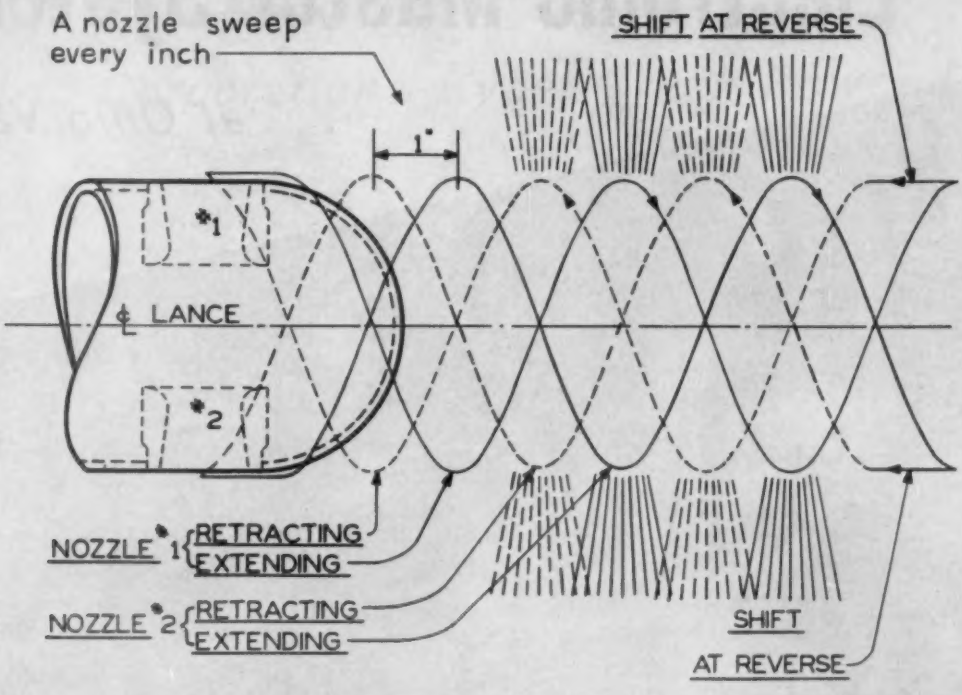


7818 SIMPLE VENTURI NOZZLE



Note the greater blowing range of the improved Diamond Nozzle when compared with a simple venturi nozzle under identical test conditions.

IMPROVED CLEANING PATTERN



Nozzle-sweep-every-inch blowing pattern assures COMPLETE coverage of ALL surface EVERY time

DIAMOND POWER SPECIALTY CORPORATION

LANCASTER, OHIO

Diamond Specialty Limited

Windsor, Ontario

OTHER ADVANTAGES OF SERIES 300 IK BLOWERS

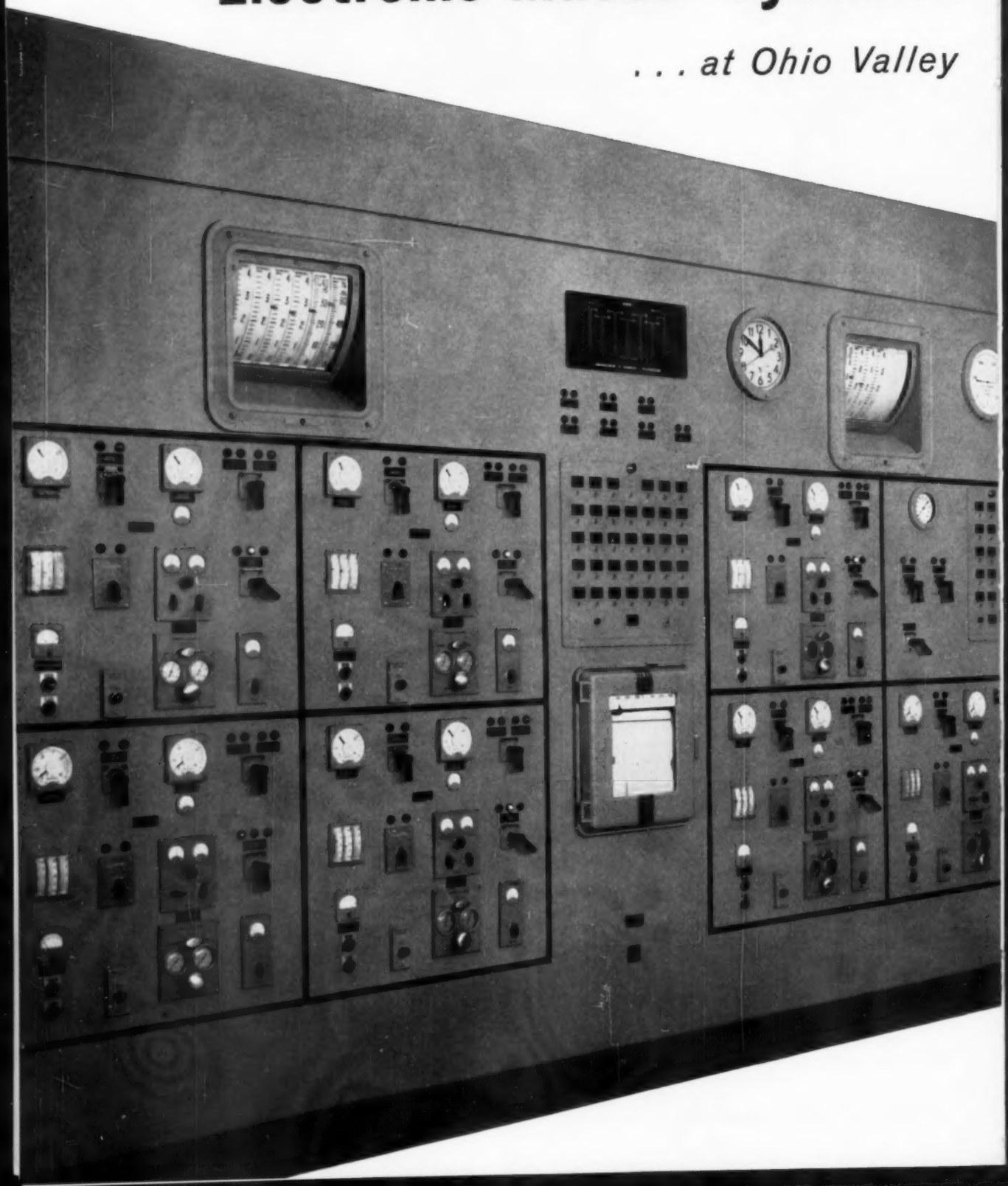
- Backbone and Protective Cover
- Front End Single-Motor Drive
- Compact, Accessible Electric Power and Control Terminal Facilities
- Positive Gear Carriage Drive
- Poppet Valve with Adjustable Pressure Control
- Positive Mechanically Operated Valve
- Single Point Outboard Suspension
- Oversize Lance (Step-Tapered for Extra Long Travel)
- Auxiliary Carriages for Extra Long Travel
- Designed for Quick, Easy Servicing

No other blower gives you all these advantages.

ANOTHER REPUBLIC ACHIEVEMENT!

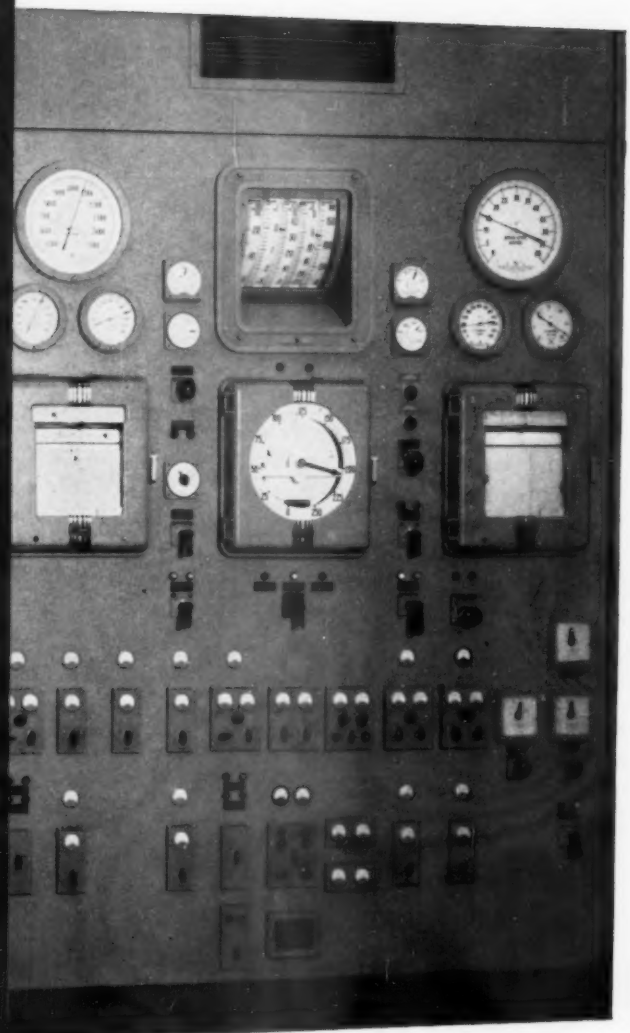
Electronic Master Systems

. . . at Ohio Valley



Control Five 1,400,000 lb/hr. Boilers

Electric Corporation's Kyger Creek Power Plant



One of Kyger Creek's five Republic control centers. An Electronic Master operates to provide electric signals for pneumatic power positioners on 7 coal pulverizers, 2 F. D. fans and 2 I. D. fans on each boiler.

Five large boilers in this plant produce a million kilowatts for our nation's atomic energy program. Multiple components on each boiler must work simultaneously as a single unit, in order to operate at maximum efficiency under all loads. A Republic *load-sensing* combustion control system with an Electronic Master regulates all these inter-related functions . . . counters every fluctuation in steam flow with corrected fuel and air flow settings without waiting for variations in steam pressure. An integral *pressure* control system makes final corrections in control signals (if necessary) to hold steam pressure constant.

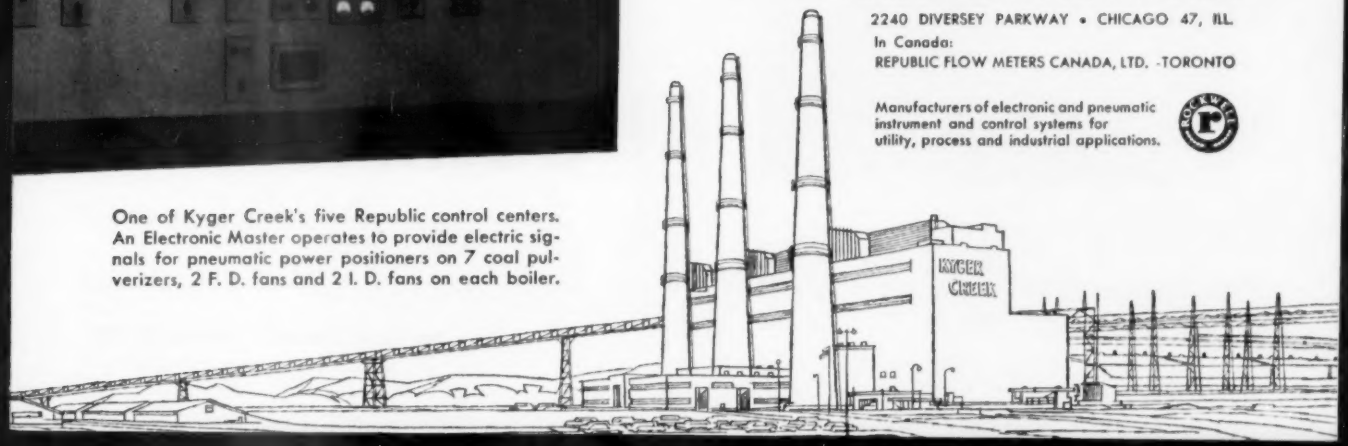
Republic's experience with plants of all sizes, all pressure and temperature ratings, and all load characteristics is your best guarantee of getting all the premium performance built into your major equipment. A technically-trained, thoroughly experienced Republic Sales Engineer is ready to discuss your instrument and control problems. Republic sales offices are located in principal cities throughout the country.

REPUBLIC
FLOW METERS CO.

Subsidiary of ROCKWELL MANUFACTURING COMPANY

2240 DIVERSEY PARKWAY • CHICAGO 47, ILL.
In Canada:
REPUBLIC FLOW METERS CANADA, LTD. -TORONTO

Manufacturers of electronic and pneumatic instrument and control systems for utility, process and industrial applications.



C-E BOILER

"Makes a hit"

AT NEW GLATFELTER PLANT

Consulting Engineer tells why...

After completion of Acceptance and Peak Load Tests on a C-E Vertical-Unit Boiler, Type VU-40, at the P. H. Glatfelter Company's new Spring Grove, Pennsylvania, paper mill, The H. M. Wilson Company, Consulting Engineers of Philadelphia, stated, "Now, having determined the results of the tests, we are happy to advise you that the overall performance of the boiler was excellent, and we feel that this particular boiler is of outstanding design and construction. We have previously commented on the excellent cooperation of your Engineering Department in the design and development of this boiler, and can only reach the conclusion that your entire organization has been most cooperative and has done a fine job."

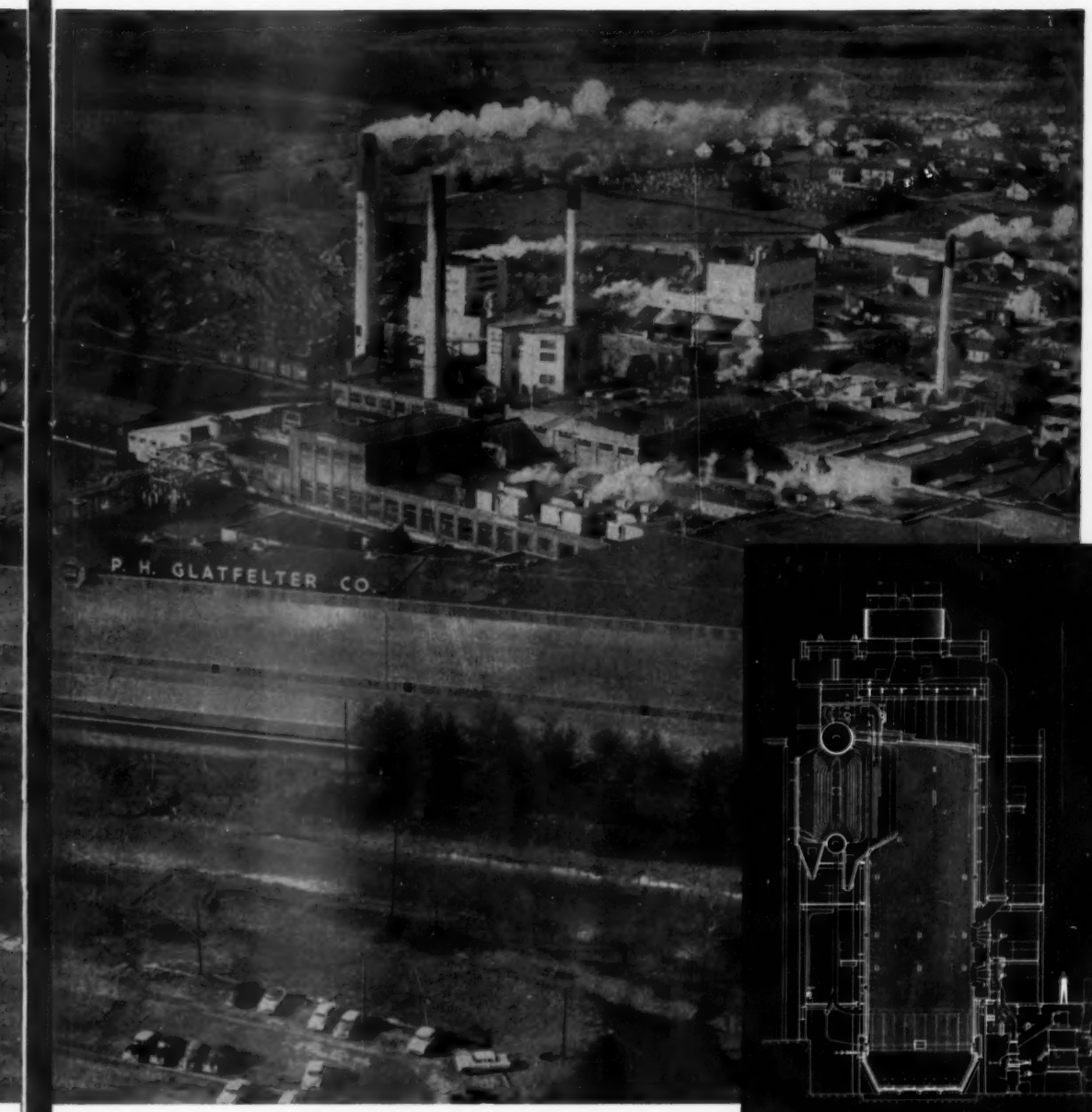
This opinion finds added significance in a statement by the company president, Mr. P. H. Glatfelter, III, who states, "We are well pleased with our choice of this C-E boiler for our new plant."

We, of course, are proud of this boiler, which, like the many other C-E installations of this and other types, is proving its superiority under actual operating conditions. When *you* need boilers, remember that Combustion Engineering has a complete line of steam generating and fuel burning equipment—a size and type that will meet your requirements exactly.

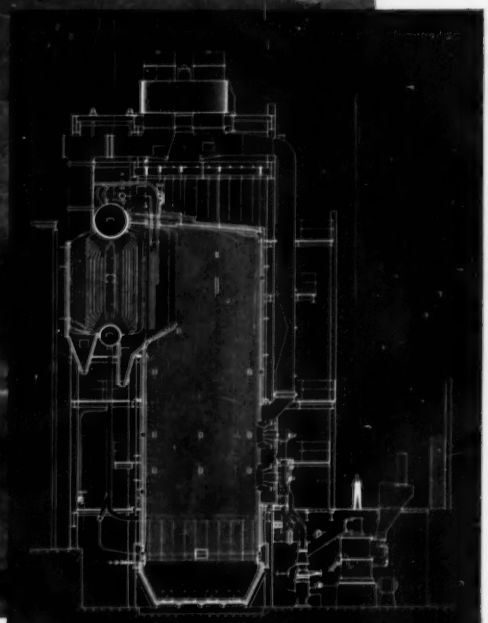
COMBUSTION

Combustion Engineering Building

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS;



The recent start-up of this new paper mill marked the completion of the P. H. Glatfelter Company's largest expansion in its 93-year history. Included in this expansion was a new Fourdrinier paper machine, a 177-acre lake, and a C-E Vertical Unit Boiler. This new mill, which is in the best tradition of modern industrial architecture, has a potential capacity of over 300-tons daily.



Cross-sectional view of the C-E Vertical-Unit Boiler, Type VU-40S, installed at the Glatfelter Paper Mill in Spring Grove, Pa. This unit is designed to burn coal or oil, either separately or in combination, with full rated capacity obtainable from either fuel. It has a maximum continuous capacity of 250,000 pounds of steam per hour at 600 psi and 650°F.

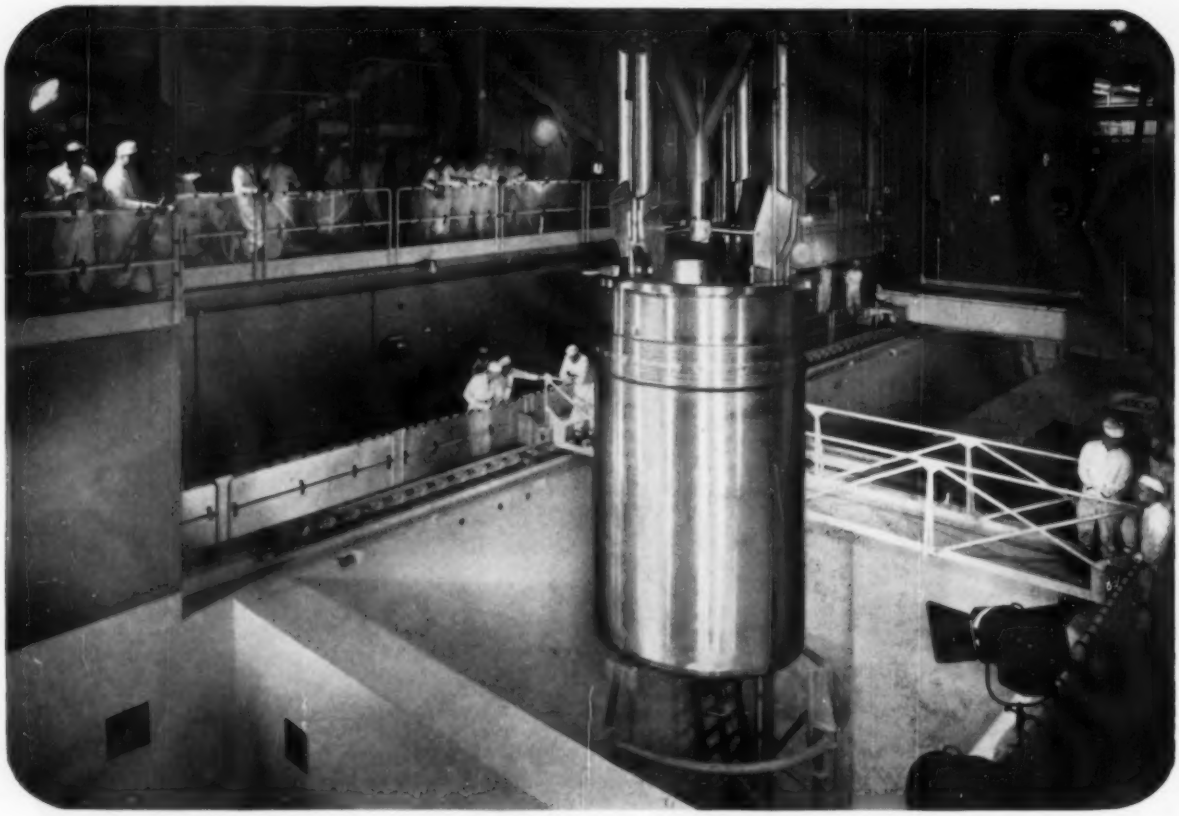
ENGINEERING

C-138

200 Madison Avenue, New York 16, N. Y.

PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

ION EXCHANGE RESINS for water conditioning



The water which shields and surrounds this nuclear core is deionized by AMBERLITE Monobed ion exchange resin units.

At the SHIPPINGPORT ATOMIC POWER STATION—where water conditioning must be efficient...dependable...fool-proof—AMBERLITE Ion Exchange Resins are used.

In this plant, built jointly by the Duquesne Light Company and the United States Atomic Energy Commission, water is the medium through which atomic energy ultimately becomes electrical energy. But this water must be completely mineral-free (1) to reduce the hazard of its metallic ions becoming radioactive and (2) to minimize "scale" formation in this plant's vital piping and heat exchange systems. For this reason, the plant's water conditioning equipment uses Rohm & Haas' AMBERLITE ion exchange resins.

After preliminary treatment of the water, calcium and magnesium ions are removed by two softening tanks containing AMBERLITE IR-120 cation exchange resin. The water then goes to a mixed bed deionization unit of AMBERLITE Monobed resin (a mixture of AMBERLITE IR-120 and IRA-400) which removes both anions and cations. The water is now ion-free. Possible pick-up of metallic ions and their build-up is controlled by passing part of the water used in the plant's primary loop through a separate mixed bed ion exchange unit containing AMBERLITE XE-154 (a specially prepared mixture of AMBERLITE IR-120 in the lithium form and AMBERLITE IRA-400 in the hydroxyl form) which raises the pH well above neutrality as a safeguard against corrosion.

For additional protection against the hazard of "hot" metallic ions, the water surrounding and shielding the reactor's core is deionized by Monobed ion exchange resin units containing AMBERLITE XE-150.

Whatever your water conditioning problem, your engineering company specializing in water conditioning is qualified by experience to recommend how AMBERLITE resins can best serve your special needs. For detailed information about AMBERLITE resins, write for our booklet *"If You Use Water."*

AMBERLITE *is a trade-mark, Reg. U.S. Pat. Off. and in principal foreign countries.*

Chemicals for Industry

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

Representatives in principal foreign countries

What do oracles say to you?

Do they assure you that your next critical piping job will be free of headaches from start to finish? You can make it so, if you deal directly with experienced specialists. In the interest of complete satisfaction, sound economy and permanent safety . . . ask us in.

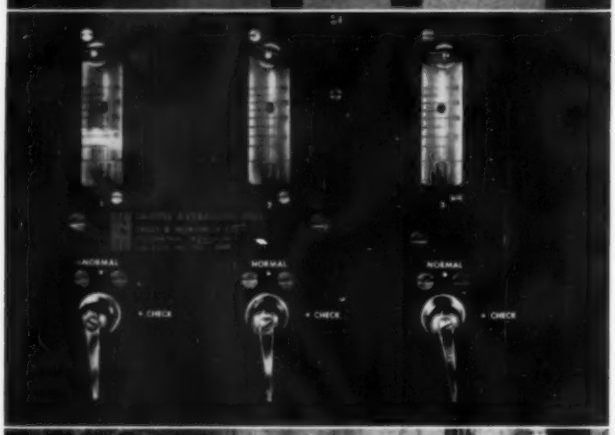
W. K. MITCHELL & CO., INC.

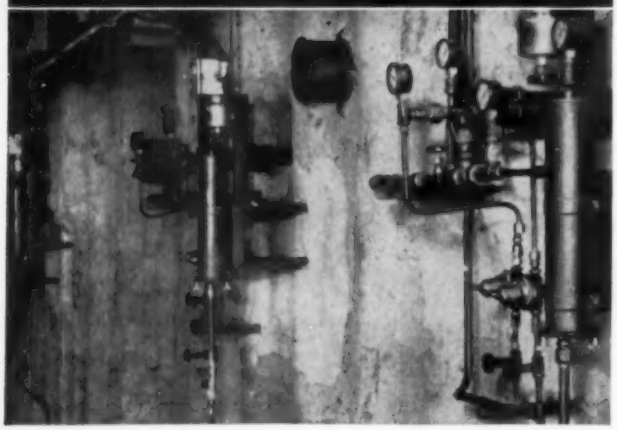
Philadelphia 46, Pa.

WESTPORT JOINT
(PATENTED)

MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS





THE NEW SPEEDOMAX O_2 SYSTEM GIVES A CONTINUOUSLY ACCURATE COMBUSTION PICTURE...

Here's why!

■ Already, on some of the country's largest boilers, this new Speedomax O_2 System is enabling operators to trim excess air automatically to maintain combustion efficiency . . . and to do it with a certainty never before possible.

Why? As one operator put it, "The System gives me a record that's meaningful. When I look at this O_2 chart I know what's *really* happening—and I know it right away."

Behind this operator's confidence is the new L&N Multiple-Probe Sample Averaging Unit which *assures a more representative sample.* This unit maintains a true average from two, three, or more probes—even if individual sample flows drop 60 per cent. And excess air distribution across the duct can be checked right at the Averaging Unit.

There is also a new Reverse Jet Probe and Steam Sampler which delivers a *clean pressurized sample* even with the *dirtiest* of flue gases. Water jets flush the probe passage continually, steam ejector action pressurizes the sample, and steam condensing action plus centrifugal separation remove all dirt and acid.

And, in analyzing and recording, the speed of response of the Speedomax Recorder, coupled with the efficient operation of the L&N Magnetic O_2 Analyzer, increases speed and accuracy of O_2 analysis and recording even further.

Why not learn more about this new Speedomax O_2 equipment and what it can do for you? Write to Leeds & Northrup Company, 4972 Stenton Ave., Philadelphia 44, Pa.

LEEDS & NORTHRUP
instruments *automatic controls* • *furnaces*

unblemished safety record

For more than 40 years, Cochrane Multiport Relief Valves have served industry with a spotless record of unfailing operation.

Not once in all these years have these valves failed to open to atmosphere to protect personnel and valuable equipment against too high pressures!

Reason for this remarkable record is their unique design. Unlike ordinary relief valves, Cochrane Multiport Relief Valves automatically e-a-s-e open under excess, undesired back pressure and bleed off only the exact unusable quantity that caused the overpressure, and then gently and tightly close—without blow-down, back surge or vapor hammer!

Cochrane Multiport Relief Valves are made of various materials to satisfy maximum operating and corrosion conditions. They function equally well whether designed for saturated or superheated steam, air or gas. Their corrosion resistant, "vapor cushion" valve discs will not rust, freeze, or stick.

For complete details write for Publication 5200.

NOTE: *Cochrane Multiport Relief Valves are adaptable to check, spillover and other services.*

Cochrane

CORPORATION

3109 N. 17TH STREET, PHILADELPHIA 32, PENNA.

NEW YORK • PHILADELPHIA • CHICAGO

Cochrane Water Conditioning Ltd., Toronto 4; Montreal 1, Canada

Representatives in 30 principal cities in U.S.; Paris, France; La Spezia, Italy; Mexico City, Mexico; Havana, Cuba; Caracas, Venezuela; San Juan, Puerto Rico; Honolulu, Hawaii; Manila, Philippine Islands.

Pottstown Metal Prods. Div.—Custom built carbon steel and alloy products.

Demineralizers • Zeolite Softeners • Hot Process Softeners • Hot Lime Zeolite Softeners • Dealkalizers • Reactors
Deaerators • Pressure Filters • Continuous Blowoff Systems • Condensate Return Systems • Steam Specialties

Dye

maker brightens fuel cost picture

Burning coal at Toms River-Cincinnati saves 20% on fuel costs, permits clean steam generation

The Toms River-Cincinnati Chemical Corp. plant in Toms River, N.J. is the most modern plant of its kind in the world. Producing vat dyestuffs requires a large dependable steam supply for chemical processes and heating purposes. To fill these requirements, the power plant at Toms River-Cincinnati is as up-to-date and efficient as the general plant itself. The fuel used for steam generation is *coal* because, on the basis of cost per thousand pounds of steam, the nearest competitive fuel costs 20% more than coal. In addition, thanks to automatic operation and modern equipment, the power plant meets the rigid standards of cleanliness required in such manufacturing operations.

Facts you should know about coal

Not only is bituminous coal the lowest-cost fuel in most industrial areas, as in the case of Toms River-Cincinnati, but up-to-date coal burning equipment can give you 15% to 50% more steam per dollar. Today's automatic equipment pares labor costs and eliminates smoke problems. And vast coal reserves plus mechanized production methods mean a constantly plentiful supply of coal at stable prices.

Technical advisory service

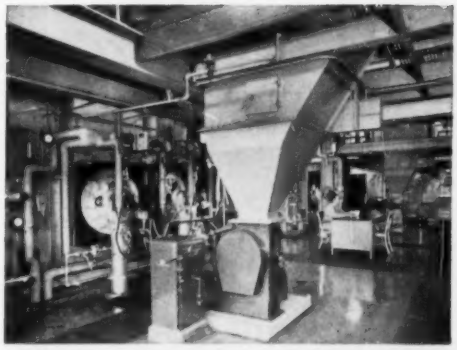
The Bituminous Coal Institute offers a free technical advisory service on industrial fuel problems. We welcome the opportunity to work with you, your consulting engineers and architects. If you are concerned with steam costs, write to the address below. Or send for our case history booklet, complete with data sheets. You'll find it informative.

Consult an engineering firm

If you are remodeling or building new heating or power facilities, it will pay you to consult a qualified engineering firm. Such concerns—familiar with the latest in fuel costs and equipment—will effect great savings for you in efficiency and fuel economy over the years.

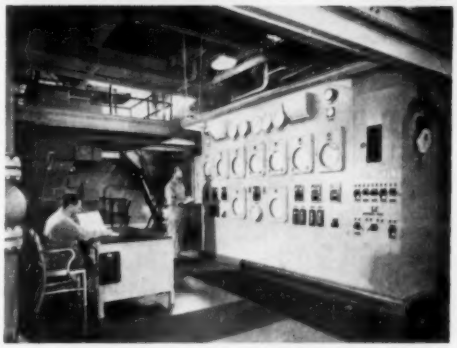
BITUMINOUS COAL INSTITUTE

Southern Building • Washington 5, D. C.

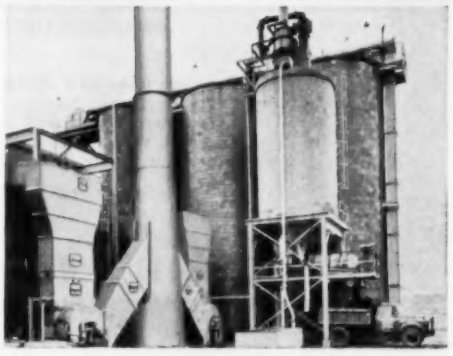


View of boiler room showing both 50,000 lbs. hr. boilers, by Riley Stoker Corp. Each has two burners. Center foreground is automatic weigh scale, by Richardson Scale Co., which receives coal through hopper from live storage bin and passes it to coal feeder. Coal is fed to Riley Pulverizer in basement, then blown back up to burners.

Close-up of Gifford-Wood Roundabout Bucket Conveyor beneath coal storage silos. Transversing feeder-car is used when coal is emptied from silo and conveyed to live storage bin.



Automatic combustion control and instrument panel by Bailey Meter Co.



Fly ash being loaded on truck through a dustless rotary unloader. Fly ash is collected by Prat-Daniel Mechanical Precipitators. A pneumatic ash collecting system by United Conveyor (with tie-ins under air heater and at base of stack) removes it to this 20-ton ash silo. In the rear are three 330-ton coal silos.

APEXIOR®
in today's power boilers

There's something basic about a power-field product with a job even more vital today than half a century ago — for technologically we've come a whole era since Apexior Number 1® first went to work inside boilers in 1906. The "why" of Apexior and its still-growing use in modern steam generators takes us, then, to fundamentals, best answered by asking—

WHAT IS APEXIOR?

Apexior Number 1® is a high-temperature, non-oxidizing, brush-applied coating for service on both heat-transfer and non-heat-transfer areas. Because it penetrates and becomes one with metal, Apexior seals surfaces at new, or newly cleaned, strength, isolating steel from its environment and establishing it as an independent element in steam generation.

WHY ARE BOILERS APEXIOR-COATED?

Maintaining the status quo to keep steel at peak efficiency is only the first benefit Apexior confers. The simple one-coat process actually transforms steaming surfaces. Because Apexior is smooth and deposit-repelling, metal stays cleaner longer — heat transfer is always at its highest — distribution is uniform — and circulation and evaporation proceed at top performance levels. Off the line, inspection is facilitated — cleaning, when required, is accomplished easily and quickly — and the boiler is soon back in better-than-ever steaming service.

WHERE IS APEXIOR IN USE TODAY?

Now manufactured in the United States and four foreign countries, Apexior serves the world around in electric utility central stations and plants generating power for every kind of manufacturing and service industry. Its first use half a century ago in Scotch marine boilers has been extended also over the years to floating power plants in vessels of every type and size.

CAN YOU APEXIOR-COAT ALL BOILERS?

Apexior serves under highest temperatures and pressures on any steam-or-water-contact area. It may therefore be applied to any water-tube boiler, including water walls, economizers, circulators, and reheat units — and to any fire-tube boiler where it serves on shell interiors and flue exteriors.

WHAT UNIT-SYSTEM AUXILIARIES ARE USUALLY APEXIOR-COATED?

- *Evaporators — interior surfaces, coil exteriors*
- *Deaerating heaters — shells and trays*
- *Feedwater heaters — interior surfaces*

WHAT PARTS OF STEAM TURBINES ARE APEXIOR-COATED?

- *Interior of casings and exterior of rotors, or wheels, and diaphragms.*

MAINTENANCE FOR METAL

This message is one of a continuing series. To be discussed: Apexior Number 1® in relation to . . . heat transfer, feedwater treatment, high-purity steam, standby, cleaning, cost. Watch for the answer to your question, or write

THE DAMPNEY COMPANY
HYDE PARK, BOSTON 36, MASSACHUSETTS

203

Automatic data processing, applied to the many variables of thermal design, results in higher efficiency of ALCO *feedwater heaters.*

HOW DO YOU FIGURE A FEEDWATER HEATER?

The trend to higher pressure and temperature in utility and industrial power plants demands *exact* design of feedwater heaters for the best heat-rate economy. ALCO, a 30-year pioneer in the heat transfer field, is again pacing the industry by focusing thermal engineering on solutions to this problem.

Advanced data on heat transfer and fluid flow from ALCO's new thermal laboratory, programmed through new electronic digital and analog computers, permits ALCO to offer the most accurate feedwater-heater thermal designs available today. Already in service and on order for the country's most efficient steam-generating plants, these heaters are proving their economy and reliability.

For more information, contact your nearest ALCO sales office or write for brochure on feedwater heaters to: ALCO Products, Inc., Dept. 132, Schenectady, New York.

ALCO

ALCO PRODUCTS, INC.

NEW YORK

SALES OFFICES IN PRINCIPAL CITIES

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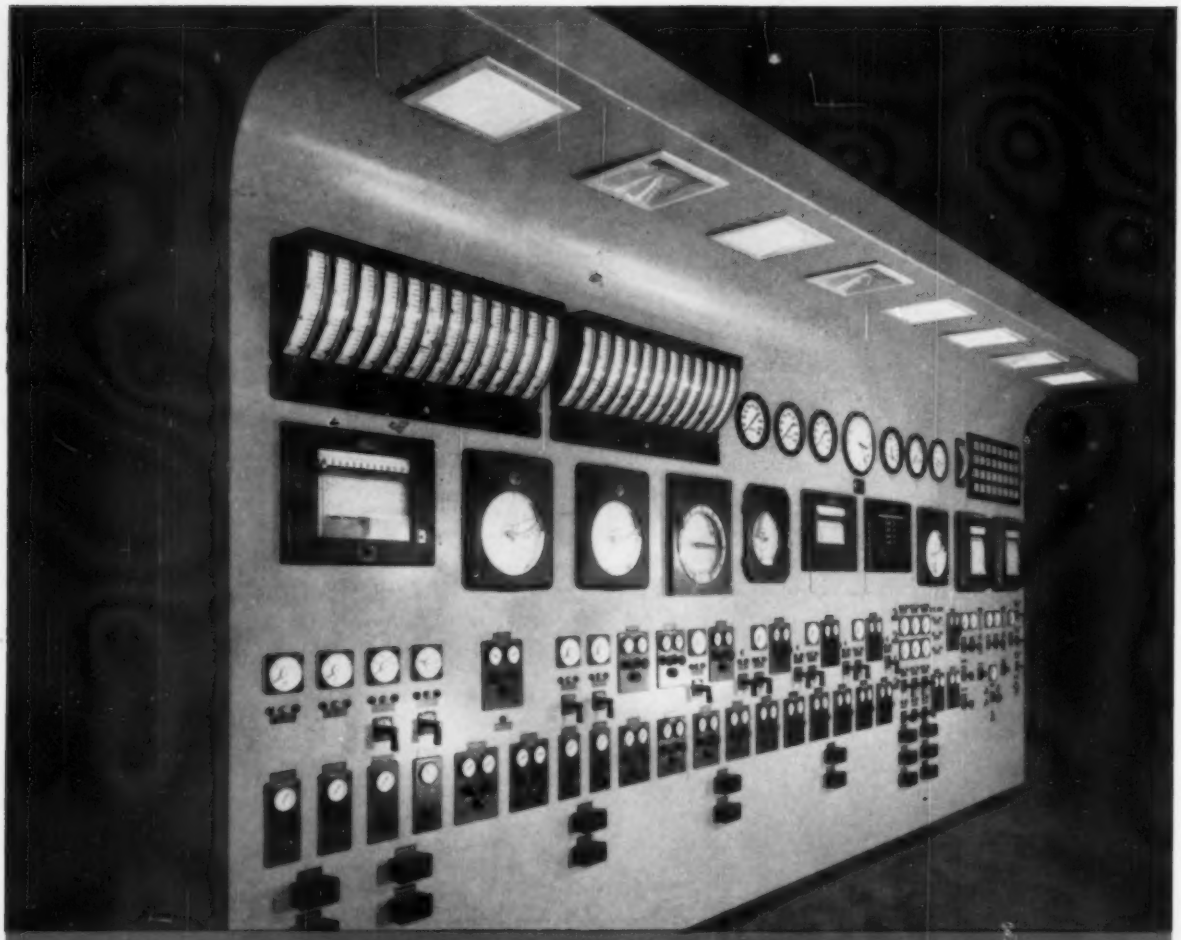


Boiler Operating Panel. Built by Copes-Vulcan, this panel provides all necessary processing information. It permits firing the furnace or feeding water to the boiler automatically or by remote manual control. Advanced Tagnetal controllers and relays simplify maintenance procedures and minimize spare parts stocks.

Copes-Vulcan Boiler Control installed at Seward Station

Pennsylvania Electric Company's Seward Station uses an integrated Copes-Vulcan system to provide efficient boiler control. Built to maintain a constant main steam-header pressure under all load conditions, this modern control system provides simplicity of circuits and dependable accuracy of components.

Correcting pressure changes automatically. Fuel feed responds to deviations in steam pressure resulting from changes in steam flow rate, and generates the exact amount of steam to restore header pressure. The system also maintains constant drum level.

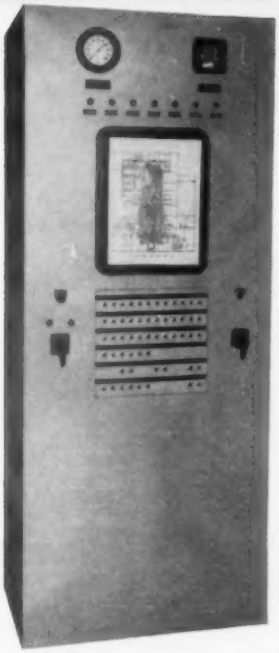
Mill temperature control, mill-totalizing circuit and boiler feed pump recirculation control are additional functions of this efficient control system.

Bumpless transfer simplifies operation. All Copes-Vulcan auto-manual stations provide a continuous picture of performance, permit automatic-to-manual selection without the complications of seal balance.

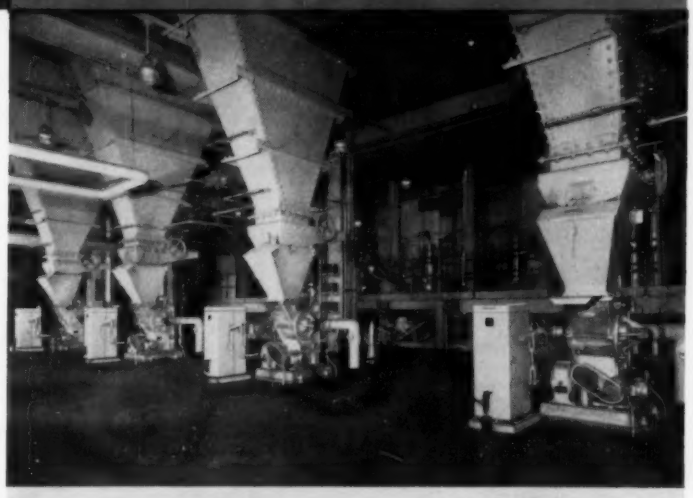
Noted for modern design, high speed response and precision performance, Copes-Vulcan boiler control systems and Vulcan soot blowing systems cut operating costs at modern stations everywhere.

Whether your boiler is large or small, power or process, your Copes-Vulcan representative has the ideas, information and experience to help you choose the system to best meet your needs.

C-V NEWS NOTES



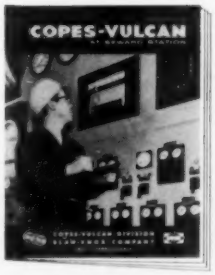
Seward's soot blower system. A Vulcan automatic-sequential control system keeps soot blowers operating in proper sequence. Panel switches permit any soot blower to be cut out of the sequence or reblown if necessary.

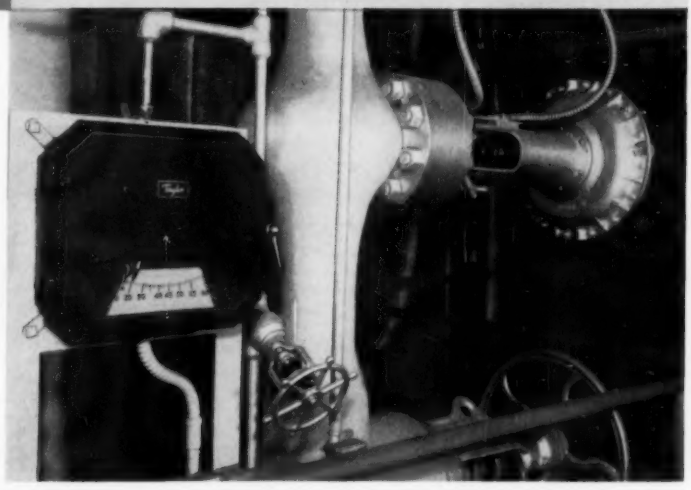


Fuel feed drive units. The units shown are typical of all drive units in the control system. A positioner, a four way valve, a power piston and feed-back cam are incorporated into each compact unit.

Pump recirculation control. When discharge from any pump falls below an established limit, an electric-contact low-flow control circuit opens a diaphragm operated by-pass valve to assure sufficient flow to prevent the pump from overheating.

Write for Bulletin 1038. This 12-page bulletin describes in detail Seward's complete control system. Schematic drawings show air-flow and fuel-loading loops. Boiler drawings locate Vulcan soot blowers and wall deslaggers.





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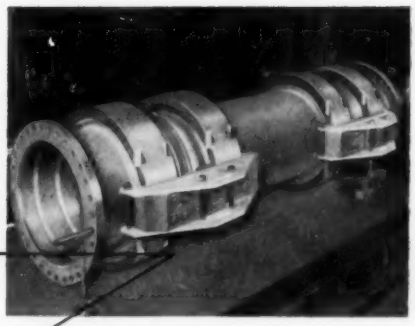

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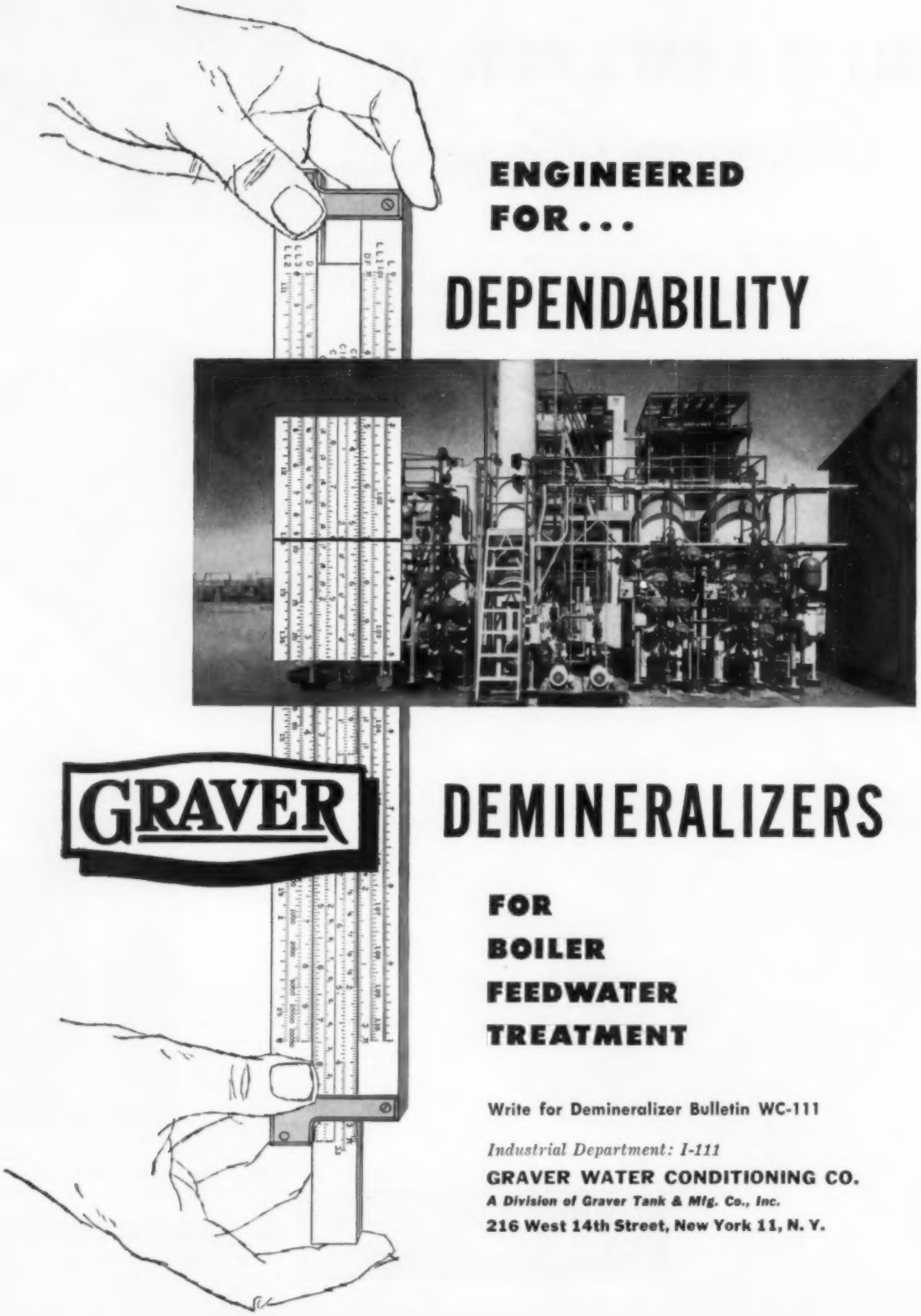

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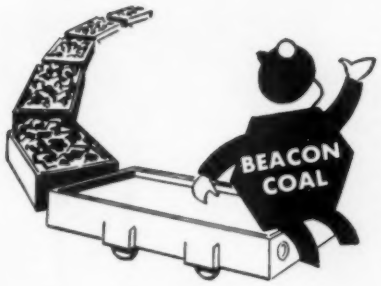

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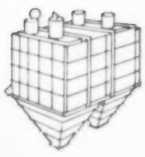

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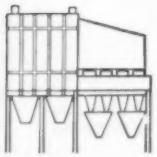

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Editorial

Making More Sites for Power Stations

Our contemporary, *Engineering*, published in England, reported in their December 6, 1957 issue an examination to be undertaken by the Central Electricity Authority of the possibilities of air-cooled exchangers and jet condensers as replacements for water-cooled towers at their stations. Should such equipment appear feasible it will materially ease the problem of finding new power plant sites.

Similarly the publication, *Energietechnik*, published in Germany, reported in their October 1957 issue on the "Heller" system developed in Hungary wherein the steam is condensed by water sprayed into a mixing condenser, part of the condensate being pumped to a specially designed air cooler in a closed circuit, the other part to a condensate storage tank. The total power consumption of pumps and fans required in this system represent 9.3 kwhr per 2000 lb of steam per hr.

The pressures of limited space and the vanishing available coastal and estuary power plant sites in England as well as on the Continent in general have forced the more forward thinking design engineers to search out ways and means of solving the condensing requirements imposed by the conventional power generating cycle. The water-cooled tower, we know, has long been a familiar solution in European plants. Here in the United States, however, it has only been comparatively recently that the cooling tower has come upon the scene. But because it has proved so valuable we feel certain the power industry in America will follow closely the studies of C.E.A. on the application of the air-cooled heat exchanger.

Some two years ago we commented on a similar interest we held for a C.E.A. study in connection with their Wakefield "B" Station. That study was the effect of the discharge of warm condenser circulating water upon river conditions. We regret that any subsequent reports or observations on this highly controversial problem have escaped us. Let us hope that our British cousins will shed some light on their findings on both the river water problem and the air-cooled tower as these studies progress. It is from such free exchange of information and findings that progress is made.

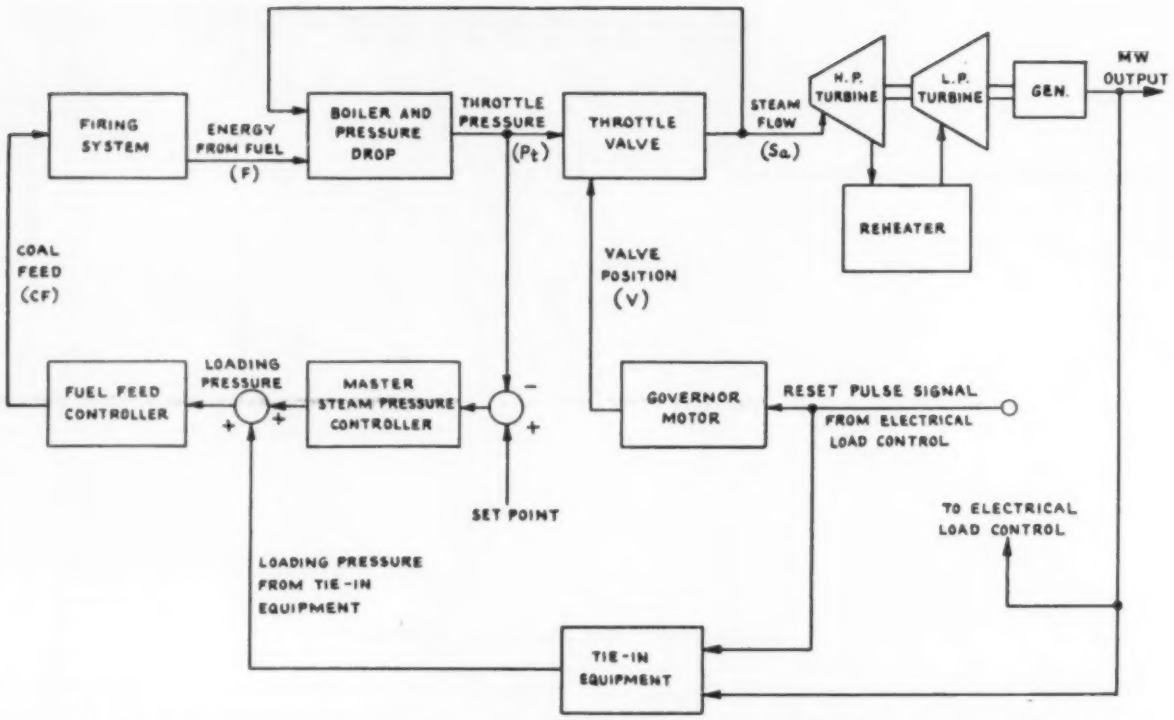


Fig. 1—Block diagram illustrates the control problem and the various inter-connections employed in its solution. (See also Fig. 12.)

Combustion Control—Load Control Tie-in Equipment*

By R. H. TRAVERS and D. B. ZELENKA,
Ohio Edison Co.

H. A. LIST and C. NICHOLS
Leeds & Northrup Co.

The success of power interchanges between systems depends basically upon each system in the interconnected group having adequate control of its generating equipment so as to recognize minute-to-minute changes in customer loads and instigate corresponding changes in generation immediately. In recent years it has become apparent that a time lag exists in boiler control systems which, if minimized, would give better system response to load changes.

IMPROVEMENT in interconnected system operation, some have felt, could come from sending regulating intelligence to the boiler control system simultaneously with load control impulses to the turbine governor. Then when the turbine responds to a changed throttle position the corresponding steam flow change would be anticipated by the boiler control system and the proper steam amount produced with less delay. Several such installations have been made. This paper evaluates the one at the Niles Station of Ohio Edison Co. The evaluation based on extensive field data and also on an analog computer simulation of the regulating system cover the performance of the tie-in between system load control equipment and boiler control at this station.

Background

The field tests were made on Unit No. 1 at Niles, which is a reheat machine with a maximum gross hourly output of 125 MW. It is supplied with steam at 1480 psi and

* Presented at AIEE Winter General Meeting, New York, N. Y. Feb. 2-7, 1958 under the title "Evaluation of Combustion Control-Load Control Tie-In Equipment At Niles Station of the Ohio Edison Co." as paper CP58-168.

1000 F by a cyclone-fired Babcock & Wilcox boiler. The unit is frequently used for regulation, receiving raise and lower control impulses from the load control equipment located in the system load dispatcher's office in Massillon, Ohio. The Ohio Edison System which includes Pennsylvania Power Co. is normally interconnected with the Cleveland Electric Illuminating Co., the Toledo Edison Co., the Ohio Power Co., and through Pennsylvania Power Co. with the Duquesne Light Co. This group operates as part of the Central-South Atlantic Interconnection, more generally referred to as the Interconnected Systems Group, the capacity of which is now in the order of 50,000 MW.

A block diagram of the control problem is shown in Fig. 1. The analog used to simulate this boiler and turbine combination is described in the Appendix. Because of various operating problems, the field tests were unavoidably delayed several times. In an effort to expedite the evaluation, it seemed desirable to use an analog computer to assist in planning the field tests as well as to predict the approximate results. The accuracy of the simulation proved quite adequate and is referred to frequently in the paper where both field and computer data are available for comparison under similar regulating conditions.

With reference to the combustion control equipment, two different master steam pressure controllers were used during the tests. The first was a two-function controller which is so designated because in responding to steam pressure variations it (1) moves the coal feed (CF) an amount "proportional" to the pressure deviation and (2) then "resets" coal feed (CF) until the steam pressure (P_T) is restored to its original value. The second controller was a three-function controller, which in addition to performing the above two functions, also moves the coal feed (CF) in response to the "rate" of change of steam pressure. Each of these controllers was tested with and without the assistance of the tie-in equipment. It can be seen by referring to Fig. 1 that when this tie-in equipment is not in service, the master controller has to determine the proper value for coal feed (CF) solely on the basis of the variations in steam pressure (P_T). Under this condition, a sustained pressure deviation must exist during load changing conditions so that the controller can reset the coal feed (CF) to the new level. With the addition of the tie-in equipment it is possible to insert a signal resulting in the proper change in coal feed (CF) required by the load change directly into the fuel feed controller without depending upon the master controller for this information.

In order to be able to evaluate the field performance accurately, the plant instrumentation had to be supplemented. Most of the test runs were made using a high speed chart drive on the unit megawatt output recorder which was also equipped with a solenoid operated marker pen that recorded the raise and lower load control impulses sent to the turbine governor. Steam pressure (P_T) and coal feed (CF), were recorded on a two-pen recorder for many of the tests. Additional test runs were made using a portable four-pen recorder for the tie-in signal, steam pressure (P_T), coal feed (CF), and megawatt output. This arrangement of information is similar to that obtained from the recorder on the analog computer and permitted convenient comparison of field and computed results. Both the recorder and its associated four amplifiers are mounted on portable racks.

Description of Tests

Since the field test program was started before the computed portion of the study was begun, the arrangement of the actual field runs was not exactly the same as those made on the computer. It proved much more convenient to make runs on the computer than in the field and as a result they could be arranged arbitrarily to give a more complete comparison of the various control arrangements. For this reason a complete set of com-

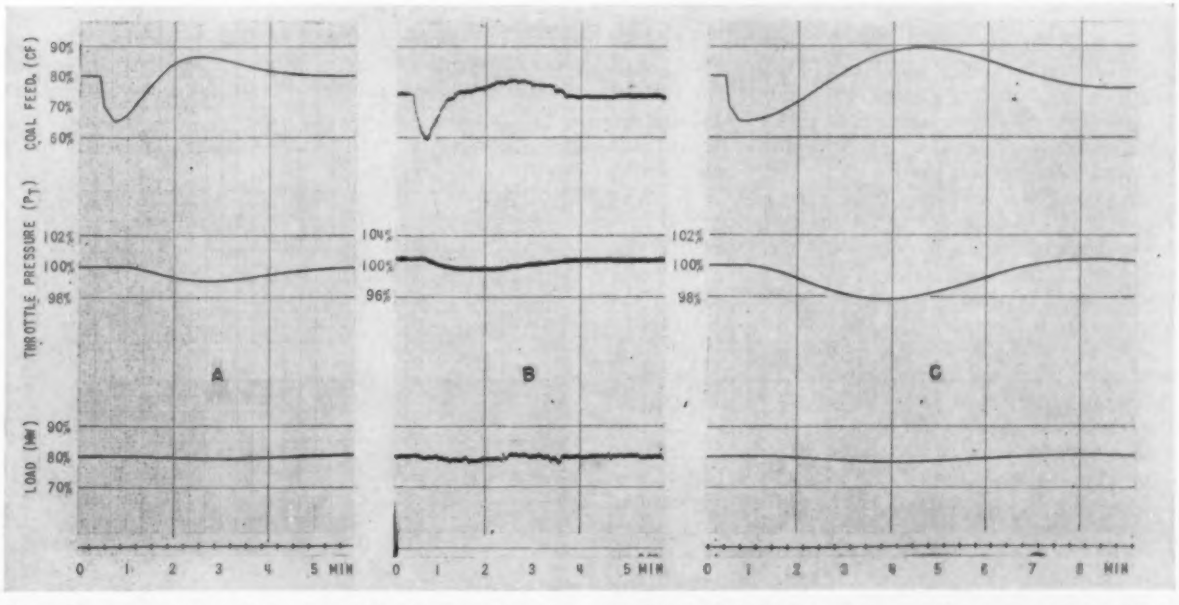


Fig. 2—Effect of fuel disturbances upon a three-function master-controller are compared when produced on the simulated computer deliberately (a) actually in the field (b) and lastly for a two-function master-controller as the computer reacts to it. **(See also Appendix, appearing on p. 40)**

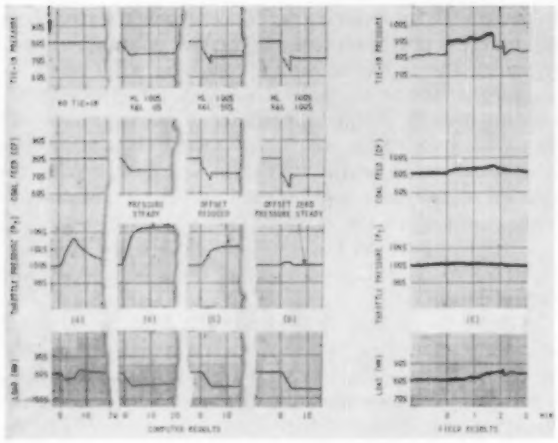


Fig. 3—With the master-controller out the computer reacts as pictured under varying adjustments. 3D is held especially important since it shows load changes can be made without pressure controller assistance by adjusting measured load (ML) and control impulse settings (R&L). 3E gives field conditions for 5 MW load rise with little pressure rise

puter data is presented with confirming field information where the latter is available for similar conditions.

Before the computer study could be regarded as reliable, it was necessary not only to verify the simulation of the boiler-turbine installation as is indicated in the Appendix, but also to establish that the control equipment had been accurately simulated. In addition, it was necessary to be certain that the same control adjustments were used in the field and in the simulation study. To illustrate this point, Fig. 2a demonstrates the performance of the three-function master controller using the settings which were found to be the most desirable for a wide variety of conditions on the computer. This shows the computed results when making a deliberate disturbance in the coal feed (CF). For a comparison with field results, Fig. 2b is included to show the actual control performance following a similar disturbance in fuel feed. During this test the same settings were used in the field on the actual master controller that were found desirable in the simulation study. The extent to which the complete system is accurately simulated is also pointed out by comparing data with Fig. 13c that are discussed in more detail in the Appendix. Typical performance obtained on the computer for a two-function master controller subjected to a fuel upset is shown in Fig. 2c. It will be noticed that the three-function controller recovers much more quickly from the fuel disturbance. The performance of the three-function controller under regulating conditions is illustrated by the load change tests reported in the following paragraphs.

The effect of varying the adjustments of the tie-in equipment when the master pressure controller has been taken out of service is shown in Fig. 3, which illustrates the results obtained on the computer. Fig. 3d is of particular interest since it illustrates that it is possible to adjust the measured load (ML) and raise and lower control impulse (R&L) settings in the tie-in equipment so that load changes can be made without the assistance of a pressure controller. It is possible to arrive at a similar adjustment of the tie-in equipment under field conditions as indicated in Fig. 3e which shows a reasonably constant throttle pressure for a 5 MW increase in generation with the master pressure controller out of service. This is, of course, conditional upon having absolutely accurate and drift-free measurements of boiler input and output. Since these conditions are not realized in practical operation, no inference is intended that a pressure controller is not required, as this device will always be necessary to correct for variables such as fuel disturbances, changes in fuel quality or changes in throttle valve position, caused by system frequency. Unless impulses are sent to the turbine governor to cause the load change, the tie-in equipment would be unable to cope with the disturbance by itself. It does follow, however, that under some conditions where the master pressure controller cannot be adjusted to provide adequately for regulating conditions, it is possible to improve the performance of a unit by adding the tie-in equipment to the combustion control.

The general pattern of the load changes used in preparing the data is as follows. On the computer, a load drop of 10 per cent was taken at approximately 2 per cent per min. on an irregular pattern to simulate load control conditions. Then a pickup of 20 per cent at 3 per cent per min. was made which was followed by a drop of 10 per cent at 3 per cent per min. Most of the field data was taken for changes of 20 per cent at 3 per cent per min. and there was always some variation in the rate of change due to valve characteristics and the effect of frequency on valve position.

Fig. 4 shows the performance of the three-function master on the computer with and without the tie-in equipment. Figs. 5a and 5b show actual field changes similar to the 20 per cent load change portion of Fig. 4. In Figs. 5a and 5b it should be pointed out that decreases in megawatt output, coal feed and throttle pressure are charts in the upward direction, which is opposite from the convention used in reporting the computer results. This inconsistency is introduced by the use of actual field records. Note that without the tie-in equipment a small but sustained pressure deviation exists during the load change but that the pressure recovers promptly when the new load is reached. With the tie-in equipment the average pressure deviation during the entire change period is nearly zero. There is a characteristic pressure deviation at the beginning of all of the changes both on

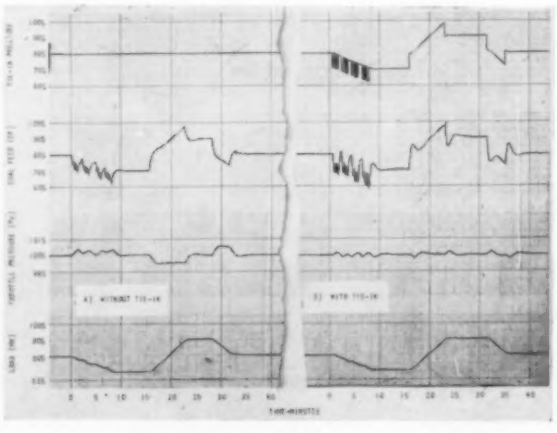


Fig. 4—Performance of three-function master controller with four cyclones as the computer reacts with and without tie-in equipment

the computer and in the field data. This is caused by the fact that the pressure drop in the main steam line between the boiler drum and the turbine throttle is modulated directly by the throttle. Because this pressure drop varies as the square of the steam flow, this effect is very much reduced at lighter loads. Since there is almost no time lag between throttle motion and steam flow change, it is not possible for the combustion control to compensate for this initial pressure excursion.

Fig. 6 compares the computed operation with and without the tie-in equipment when the unit is operating at a reduced load with only three of the four cyclones in service. Fig. 7a and 7b were taken under similar conditions in the field, and the direction for increases in the measured quantities should be noted as in Figs. 5a, b above. Two effects have combined to handicap the master controller. First, the pressure deviation resulting from the modulation of the pressure drop by the throttle is only about half as large as it was at the higher load. Thus, the initial pressure deviation at the beginning of a load change contains less intelligence for the master controller to use. Secondly, the master controller has only $^3/_4$ of the coal feed equipment available to follow its output. Consequently, its output must move further for a given effect on coal feed and this can only be obtained if the pressure deviation is increased.

However, when the tie-in equipment is in service at this lighter load, pressure deviations are substantially smaller for two reasons. The fact that the pressure deviation resulting directly from throttle motion has become smaller is no longer a liability but is actually an advantage, as the initial deviation is smaller. Also, the tie-in equipment is so designed that it recognizes there are only three cyclones in service, and the signal from the tie-in control can correct fuel to absorb the load change without direct assistance from the master controller as mentioned above. Since the need for assistance from the master controller has been minimized, large pressure deviations are not required. It is also possible for the pressure deviations to average zero during the load change period. Because of irregularities in throttle valve motion, the pressure deviations obtained by actual field tests are not as small as those obtained on the computer when using the tie-in equipment.

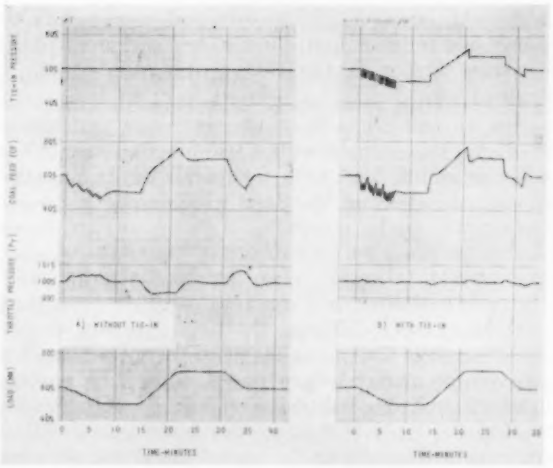


Fig. 6—Computed operation is compared with and without tie-in equipment under a reduced load

From a regulating standpoint, it is extremely important to minimize the overshooting of megawatts after the load control impulses have stopped. With minimum overshoot the unit will respond faster in either direction. Referring again to Figs. 7a and 7b which illustrate the field results with and without the tie-in equipment under the three cyclone condition, the megawatt response will now be examined. In Fig. 7b, an 18 MW decrease at 4 MW per min. was made and it will be noted that with the tie-in equipment in service, the maximum throttle pressure deviation was about 10 lb with an average approximating zero during the change. The megawatt load stabilized almost immediately after the last impulse was sent to the governor. In fact, the pressure was actually on the low side of its control point when the last lowering impulse reached the governor, thereby partially compensating for the lag in the reheater and minimizing any tendency for megawatts to overshoot. Without the tie-in equipment, the pressure variations in Fig. 7a were definitely larger, reaching a maximum of 15 lb with the deviation on the high side during the entire change. Of greater importance is the fact that approximately 40 sec were required for the megawatt output to reach a steady value after the last impulse. The fact that the pressure was 12 lb high when the last lowering impulse reached the governor definitely contributed to the megawatt overshoot. Thus, at this reduced megawatt output, the tie-in equipment contributes substantially to the regulating capability of the unit.

It is to be expected that the trends indicated by the change from four to three cyclones will also be observed if the load is reduced further and only two cyclones are used. This condition was simulated and the results were shown. Because of system load and economy conditions which prevailed during the field test periods, field data is not available for two cyclone operation. The tie-in

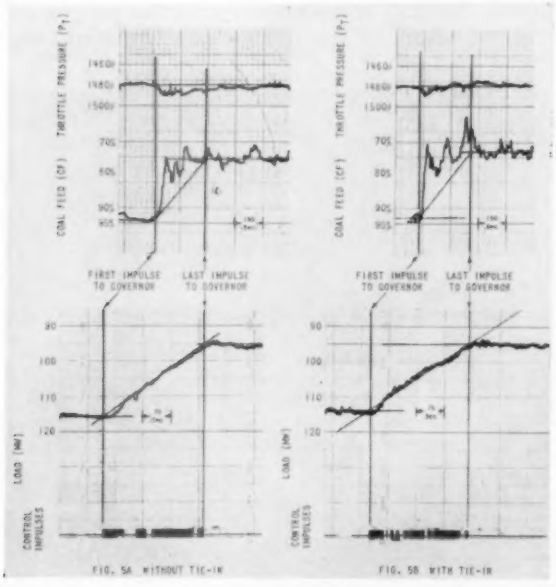


Fig. 5—Three-function master-controller with four cyclones produces these field results at Niles. Note the chart speed of CF and P_T record only half that of the MW one

equipment, however, is also arranged to recognize the change in conditions from three to two cyclones and performance similar to the computed curves should be obtained.

Figs. 8a and 8b indicate the computed performance which can be expected with a two-function master controller near full load with four cyclones in operation, showing the effect of the tie-in equipment. Field data taken under similar conditions is shown in Figs. 9a and 9b and the direction for increase in the measured quantities should be noted. Two deficiencies are apparent when this performance is compared with that of a three-function master. Without the tie-in equipment, pressure deviations have to be larger to carry the same load pattern, and a much longer time is required for restoring steady operating conditions. It can be noted in Fig. 8b that the tie-in equipment can make substantial reductions in the pressure deviations associated with load change conditions, but the time required for recovery from any upset is not improved. Because of the operating flexibility and improved performance associated with the three-function master controllers, these devices have replaced the original two-function master controllers initially installed at Niles.

An experimental oxygen installation which obtained its measurement at the discharge of the "A" cyclone was in service during the early field tests. This indicated that oxygen varied normally in a band approximately 1 per cent wide at steady load and that there were no striking changes in this record associated with the load change tests. This is to be expected since when cyclone firing is used, the master pressure controller changes both fuel and air in a parallel manner for each individual cyclone.

Samples of the normal operating records obtained with the tie-in equipment and three-function master controller are shown in Figs. 10 and 11 for the period from midnight to 6 a.m. on Sept. 18, 1957. In the period from midnight to 3 a.m. load changes were made for comparison with the results obtained previously on the computer. From midnight until 2 a.m. tests were made with four cyclones

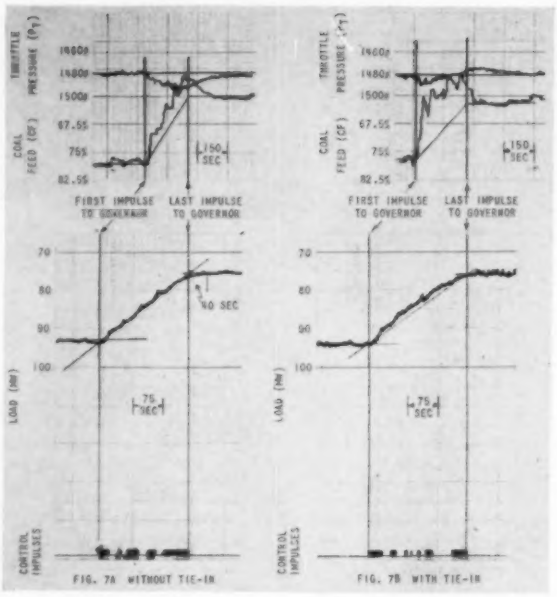


Fig. 7—Similar conditions to those of Fig. 6 are pictured as they appear under actual field changes. Note scale readings are reverse of usual

in service. From 2 to 3 a.m. a similar load pattern was used with three cyclones in service. From 3 until 6 a.m., the unit was available for system regulation, most of the actual regulating occurring between 5 and 6 a.m. The MW chart shows that the load changes were made at a rate approximating the maximum limit recommended for the turbine. The three-pen boiler chart shows steam flow, steam pressure and air flow for the same period. The time markings on the MW chart correspond to the time scale for the steam flow record. The air flow record is displaced approximately 20 min in a counter-clockwise direction. The steam pressure record is displaced an additional 10 min. in the same direction. The similarity between the shape of the steam and air flow records indicates the ability of the combustion control to match

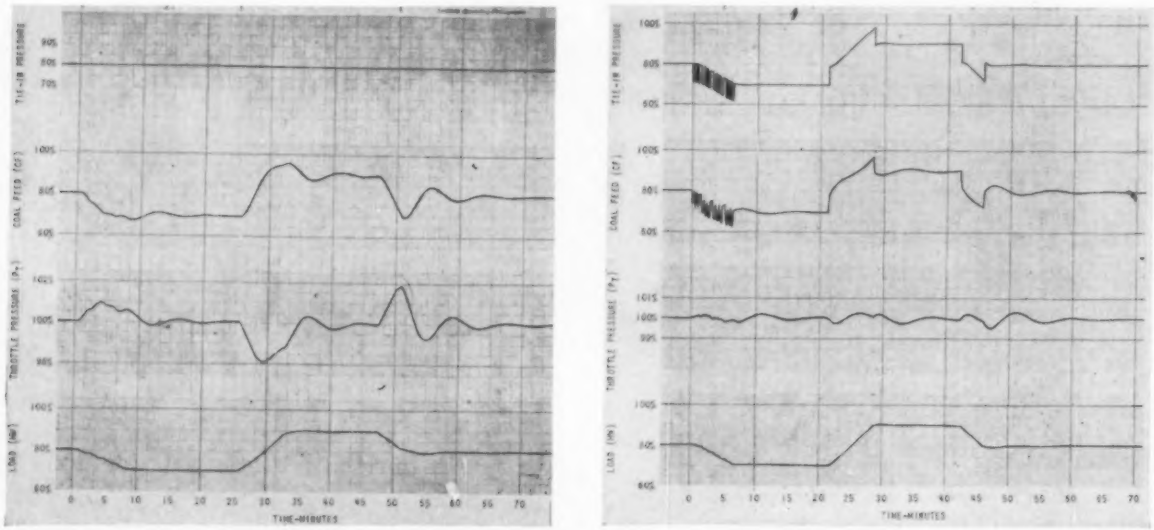


Fig. 8—Computed performance to be expected with a two-function master-controller near full load with four cyclones appear above both with tie-in and without tie-in equipment, on the right. This compares with Fig. 9, a and b, for field conditions. Note reductions in pressure deviations

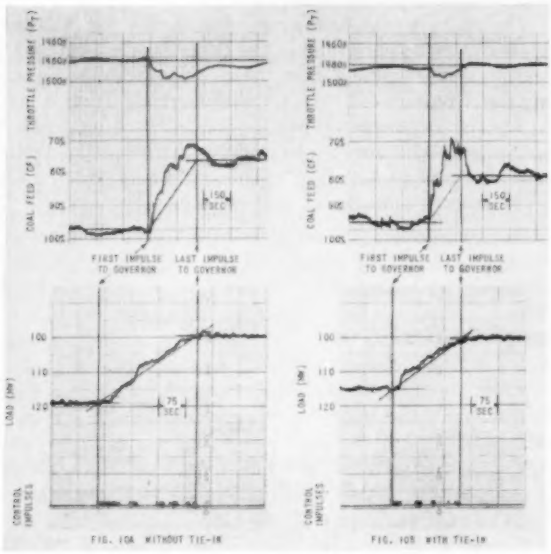


Fig. 9—Field data taken under similar conditions to those of Fig. 8 are portrayed in the above. Again CF and P_T charts record half that of the MW chart

boiler input and output. The air flow is following the sum of the outputs of the master pressure controller and the tie-in equipment rather than steam flow. The fact that all of the pressure deviations are included in a band only 20 psi wide indicates the need for the supplementary instrumentation used to examine them. It also indicates that these deviations have been reduced to relative unimportance both when the unit is being used for regulation and at steady load.

Conclusions

The results obtained with the combustion control-load, control tie-in equipment on Unit No. 1 at Niles Station has indicated the following evaluation:

1. The three-function master pressure controller, incorporating proportional, reset and rate actions, provides excellent regulating characteristics above approximately 70 per cent rating. Performance at lower loads is impaired by the reduction in steam pressure drop from the drum to the throttle. The use of the tie-in equipment compensates for this effect at lower loads and improves the regulating capability in this load range without appreciably affecting the full load performance. Benefits from the use of the tie-in equipment at reduced output are two-fold, as follows: (a) improved throttle pressure regulation, and (b) more stable megawatt output requiring less time for load to become constant after the load control impulses stop.

2. The two-function master pressure controller, providing only proportional and reset actions, when operated by itself imposes some limitation on the regulating capability of the unit even at full output. When supplemented by the tie-in equipment, acceptable performance under regulating conditions can be obtained down to approximately 50 per cent load.

3. There was no indication that the improved regulating characteristics obtained with the tie-in equipment were obtained at the expense of combustion efficiency since the fuel and air to the cyclones were controlled simultaneously and no appreciable changes were noticed in the oxygen reading near the output of the cyclones.

A word of caution is in order with respect to the extent to which the above conclusions may be generalized to other boiler-turbine units. The settings which were used on the three-function master pressure controller for these tests both on the computer and in the field are somewhat "tighter" than settings which provide the same degree of stability on many other boilers. Any limitation which another type or size of boiler may impose that requires "looser" settings of the master controller will, in general, place some limitation on the regulating characteristics that could be obtained without the tie-in equipment. More improvement would undoubtedly be realized if tie-in equipment were used on these installations than was experienced at Niles. Conversely, it would also be true that if boiler constants would permit "tighter" master controller settings there would be less benefit from the use of the tie-in equipment.

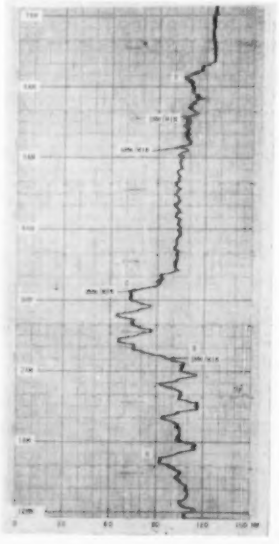


Fig. 10—Actual megawatt record taken during Niles tests

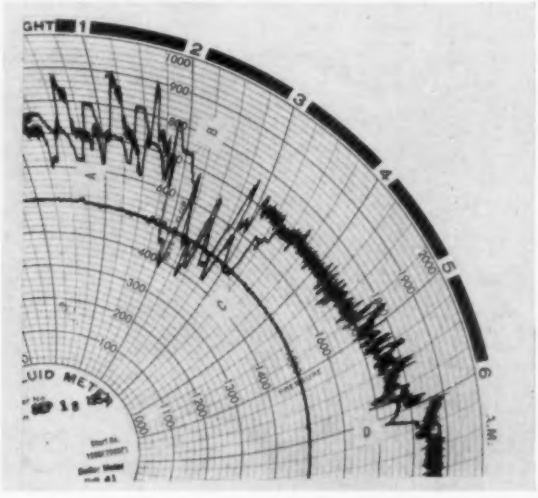


Fig. 11—Actual steam flow, air flow and steam pressure test records

In addition to the above conclusions which pertain to plant operation there is a definite benefit to the Ohio Edison system in meeting its regulating obligation to the Interconnected Systems Group. This tie-in equipment enables the plant generation to respond more quickly to the load control signals and minimize the amount of overshoot. These two features are of definite benefit in meeting instantaneous regulating demands.

The authors wish to express appreciation for the assistance of various personnel in the Ohio Edison System Operating Department and at the Niles Station in conducting the necessary field tests. Specific recognition is given to Mr. E. T. Scheatzle, Mr. A. R. Goddard, and Mr. E. L. Evanoff who assisted materially in the actual testing program, and to Mr. J. W. Schwartzenberg of the Leeds & Northrup Simulat on and Analysis Section.

Appendix-Description of Simulation

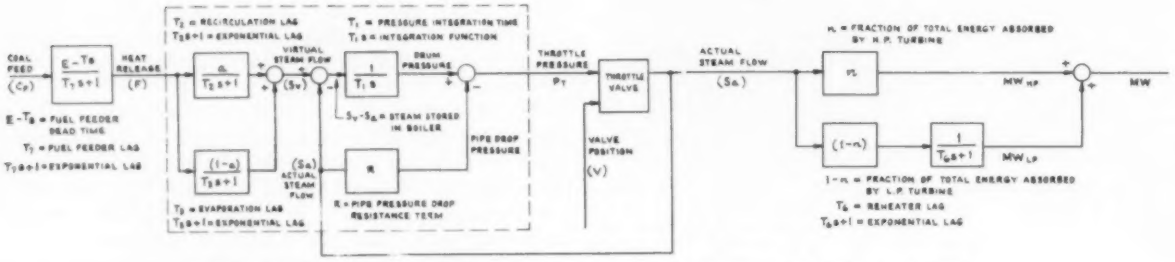

COAL FEED (Cp)
E-To / Ty s+1
HEAT RELEASE (F)
E-To = FUEL FEEDER DEAD TIME
Ty = FUEL FEEDER LAG
Ty s+1 = EXPONENTIAL LAG
T2 = RECIRCULATION LAG
T2 s+1 = EXPONENTIAL LAG
a / T2 s+1
(1-a) / T3 s+1
VIRTUAL STEAM FLOW (Sv)
(Sa) ACTUAL STEAM FLOW
T3 = EVAPORATION LAG
T3 s+1 = EXPONENTIAL LAG
T1 = PRESSURE INTEGRATION TIME
T1 s = INTEGRATION FUNCTION
1 / T1 s
DRUM PRESSURE
Sv-Sa = STEAM STORED IN BOILER
R
PIPE DROP PRESSURE
R = PIPE PRESSURE DROP RESISTANCE TERM
THROTTLE PRESSURE PT
THROTTLE VALVE
VALVE POSITION (V)
ACTUAL STEAM FLOW (Sa)
n = FRACTION OF TOTAL ENERGY ABSORBED BY H.P. TURBINE
n
MW HP
MW
(1-n)
1 / Tb s+1
MW LP
1-n = FRACTION OF TOTAL ENERGY ABSORBED BY L.P. TURBINE
Tb = REHEATER LAG
Tb s+1 = EXPONENTIAL LAG

Fig. 12—Operational block diagram of the firing system, boiler, throttle valve, turbine and reheater

The Berkeley EASE Computer in the Leeds & Northrup Co. Research & Development Department was used for simulation study by J. W. Schwartzenberg, L & N.

Fig. 12 indicates the operational Block Diagram of the Firing System, Boiler, Throttle Valve, Turbine, and Reheater. Starting in the upper left hand corner, the time delays between a change in coal feed (CF) and the heat release in the furnace (F) are represented as a combination of a short dead time (T8) and a single time constant (T7). This heat release is divided between the heat (a) which appears in a relatively short time (T2) as additional steam production (Sv) and the heat (1-a) which is delayed longer (T3) because it has to be added initially to the water in the circulating system. The values used for these numbers had to be estimated and refined to obtain correlation between the simulated and actual steam pressure (P_T) records in Figs. 13a and 14. The difference between actual steam flow (Sa) and steam production or virtual steam flow (Sv) is then applied to the block representing boiler storage (T1). The steam pressure which is available at the throttle (P_T) is then the difference between the output of the storage block (which is essentially drum pressure) and the term R which represents the pressure drop associated with the steam flow (Sa). The magnitudes of these time constants and ratios were adjusted to make MW and (P_T) records in Figs. 13b and 15 coincide. The steam flow is considered as being affected similarly by either a pressure change (P_T) or a change in valve position (V).

The assumption was made that the high pressure section of the turbine converts a portion (n) of the steam flow (Sa) directly into output (MW). The contribution

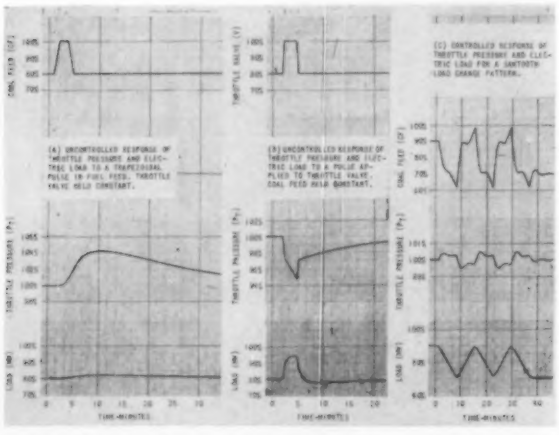


Fig. 13—Simulated boiler response in throttle pressure and load to a pulse in fuel feed case with throttle valve constant (a), to a pulse applied to the throttle valve, fuel feed constant (b), and to a sawtooth load change (c)

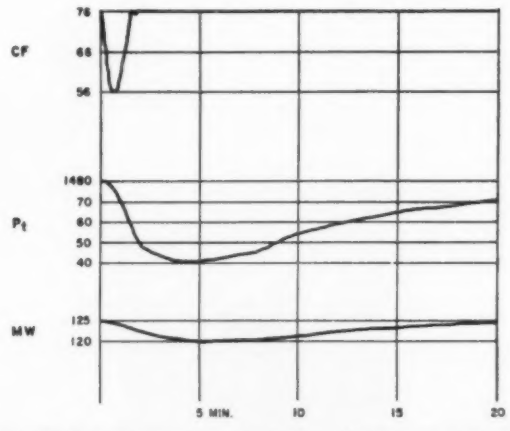


Fig. 14—Field conditions as they actually showed in response to the conditions of case (a), Fig. 13 are diagrammed above

(1-n) of the low pressure portion of the turbine is delayed (T6) by the volume of the reheater and associated piping.

The methods used to simulate the master controller, fuel feed controller, load tie-in equipment and the control of the throttle valve by the governor motor were performed in a similar manner. The three-function master controller used in the field is the L&N Cat. 11116 pneumatic controller. This controller is provided with an interlock between the settings of the reset and rate functions. This is required by the techniques used to generate these functions. The simulation of this controller was schematically identical, and the same limitation on combinations of reset and rate were observed on the computer. The simulation of the control equipment boiler-turbine combination was verified by comparing Fig. 13 made on the computer with data taken in the field. The tie-in equipment is electronic and could be simulated directly. The governor motor control of the throttle valve which is directed by the load control from Massillon was simulated to include the time delays associated with slow and small movements of the governor motor.

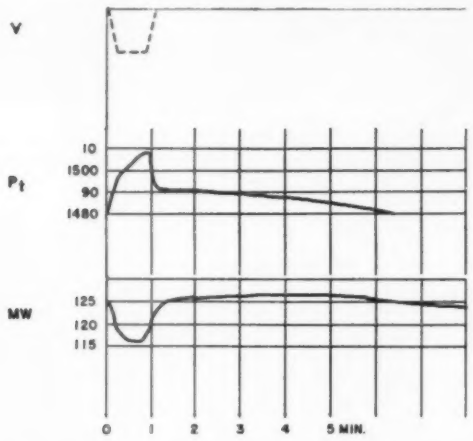


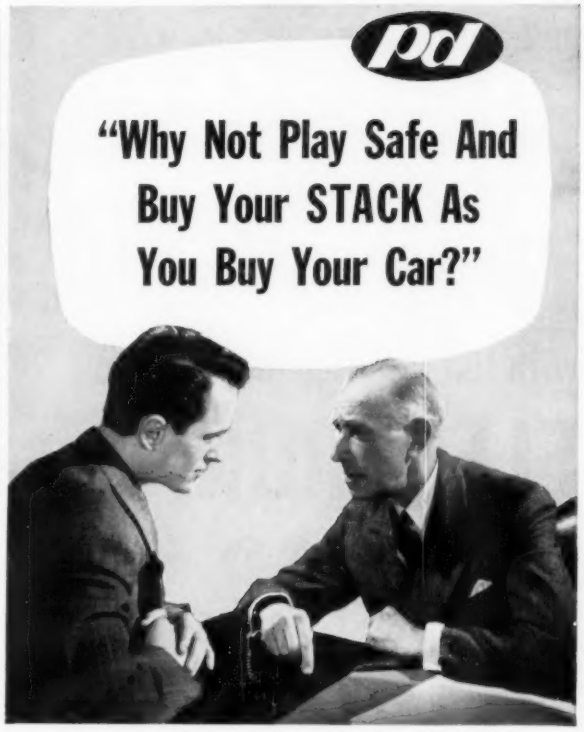
Fig. 15—Similar to Fig. 14 above chart shows actual field response to the conditions imposed in case (b) of Fig. 13

Educators Offered Nuclear Training

Nine institutes on nuclear energy for engineering educators will be held throughout the nation this summer under the sponsorship of the Atomic Energy Commission and the American Society for Engineering Education.

These institutes provide special training in nuclear energy and the nature of nuclear reactor problems so the teachers can incorporate this material in their teaching programs. There will be four basic courses for teachers with no special background in nuclear energy, four advanced-level courses and one new basic course for teachers in technical institutes.

Each of the basic institutes will be combined programs of a university and a national laboratory, with a quota of from 25 to 30 participants at each location. The dates for all are June 23–August 15 and the locations are: North Carolina State College, Raleigh, with Oak Ridge National Laboratory; Cornell University, Ithaca, with Brookhaven National Laboratory; Purdue University, Lafayette, Indiana with Argonne National Laboratory; and University of California at Berkeley with Radiation Laboratory at Livermore.



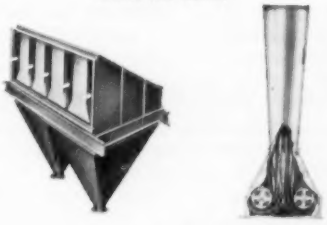
"Joe, you wouldn't buy the engine of your car from one manufacturer, the wheels from another and the body from still another, would you? Neither would I. And when I design for induced draft, I specify a P-D Stack because the I.D. Fan, though it is important, isn't the whole story. The combined breeching, stack and fan, built as ONE apparatus, gives me unit responsibility, compact design, simplified engineering, and positive performance, with a lot less purchasing details.

"Another thing, I'd rather buy my Dust Collector from the same manufacturer that made my Stack and Fan. For this is all part of the same system for handling the gas after it leaves my boiler unit.

"There's nothing like putting all the responsibility on ONE manufacturer's shoulders if you can, for then you'll come out on the long end nine times out of ten. Buying such equipment piece-meal is antiquated and costly."

You can save a lot of time, trouble and money by purchasing your Stack and Dust Collector from Prat-Daniel.

Write for data.



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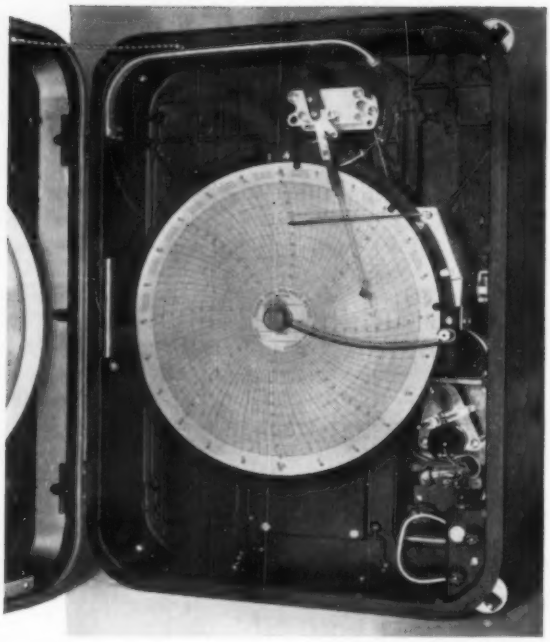
RING BALANCE FEATURES No. 4

ELECTRIC TRANSMISSION

with the versatile new PowrLog

ELECTRONIC RECEIVER



Complete assembly with amplifier in place. Flow integrator may be added for complete records.

The Hagan PowrLog Electronic Receiver brings a new standard of accuracy and dependability to the remote transmission of all standard variables. In applications where the transmitter is a Ring Balance meter equipped with slide wire, the PowrLog receiver can record, integrate and indicate fluid flow with or without compensation for pressure and temperature, fluid density, liquid level in open or closed vessels, boiler drum water level. Used with suitable amplifiers, the field of application widens to include temperature, heat exchange and other variables.

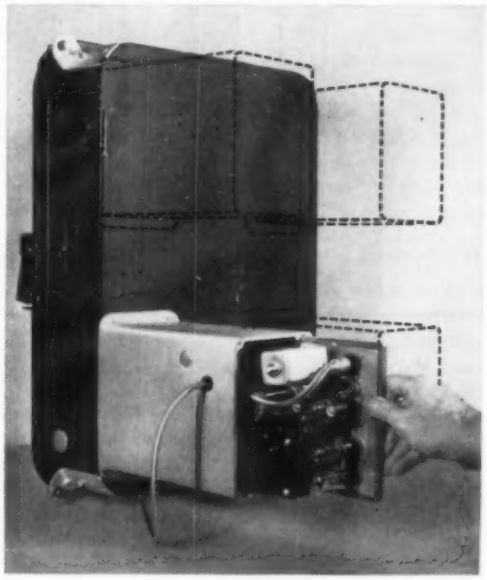
Interchangeable, plug-in, input boxes quickly adapt the PowrLog to operation with AC or DC inputs. Up to four records can be made simultaneously or control can be accomplished through coupling to the Ring Balance pneumatic transmitter-controller.

Unaffected by mechanical friction or power supply fluctuations, the PowrLog offers these operating characteristics:

Resolution	0.15% of full scale
Repeatability	0.25% full scale
Over-all Accuracy	0.5% full scale
Pen Travel Time	2 seconds full scale (0.5 sec./inch)

Input Ranges:

AC Bridge	1000 ohm transmission potentiometer
DC Potentiometer	0-0.1 v. to 0-1.3 v.
DC Voltmeter	500 volts maximum



Printed circuit amplifier chassis slides readily into housing. Note that as many as four units may be used in a single instrument case.

Remember, the Hagan Ring Balance meter offers you all these features, too:

1. Ease of calibration under operating static pressures with factory calibrated check weights matched to each meter. No more four-story water columns and telephones!
2. Safe operation with rings rated at 2,500, 6,000, 15,000 psig. No gaskets, no stuffing boxes.
3. Sealing fluid density and level not critical. No eyedroppers required to maintain calibration.
4. Interchangeable ring assemblies for full scale ranges from 0.5" w.c. to 560" w.c. Adjustment on any one ring over a 7:1 differential range easily and quickly accomplished.
5. Wide range computation and/or compensation by means of built-in, easily checked mechanisms available on most models.
6. Any Ring Balance meter can be equipped with slide wire for operation with data-logging devices and for transmission to the PowrLog.

For full details on the Hagan PowrLog, write for Bulletin MSP 149.

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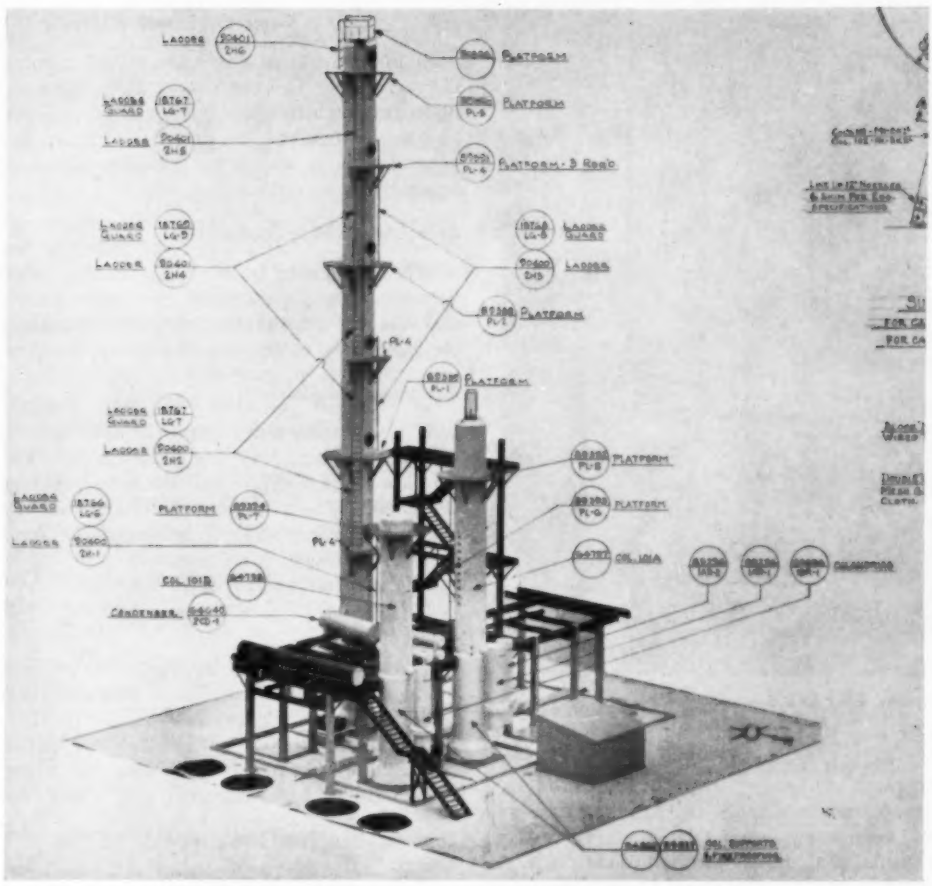


Fig. 5—Equipment location drawing made from a picture of a scale model

Some Uses of Photography in Engineering*

By W. C. FOULKE

Eastman Kodak Company

This subject while considerably out of the ordinary for a power field publication seemed, to our thinking, to be uniquely rich in possibilities. The speed and accuracy of ordinary snapshots taken by engineers can be used to reduce costs in almost all phases of engineering projects. This paper discusses some ways in which still photography is applicable and shows how photographs are used to reduce costs. Suggestions for the purchase of equipment and supplies and for the training of personnel also are included.

THREE basic forms of a photograph which are useful for engineering work are the marked print, the unmarked print with a translucent overlay, or a picture reproduced on a photographic translucent overlay, and a picture reproduced on a photographic translucent material such as paper, film or sensitized tracing cloth. These choices we discuss in this paper.

* Presented before the ASME Annual Meeting, New York, N. Y., December 1-6, 1957 (As Paper No. 57-A-155).

Field instructions can be given by marking changes on one or two photographic prints with a wax negative pencil and giving the photograph to the construction foreman. For clarity the print could be enlarged like Fig. 1, p. 44 and any number of prints obtained. A variety of photographic techniques extend the scope of application.

Marked Print

When a number of photographs are to be released at

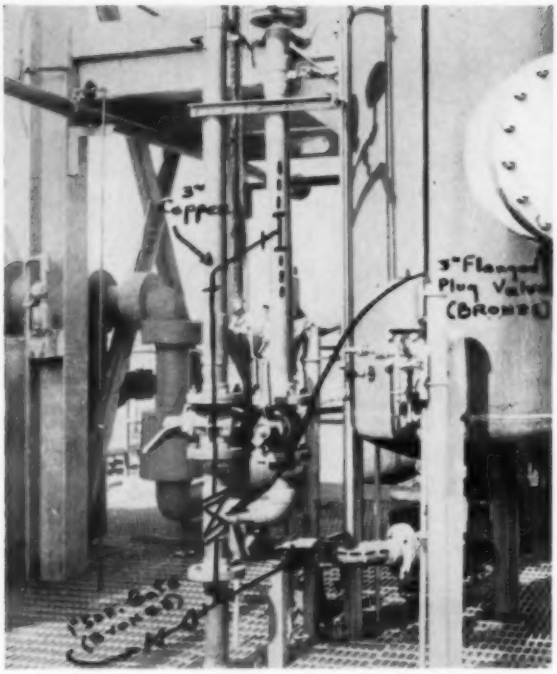


Fig. 1—Marked photographic print carries field instructions for proposed piping changes

one time, it is often convenient to paste the prints on a sheet of drawing paper and mark the prints with a wax pencil. Any explanatory notes can then be written between the prints, and the sheet forwarded to the job site. If more than one copy is needed, positive photostats of the original can be made.

This method of presentation is often used when a permanent record of the release is not required and an informal presentation is adequate.

Translucent Overlay

If extensive changes are to be shown on a print and it is not necessary to retain a permanent record or copies, a convenient and clear presentation can be obtained by pasting the unmarked prints on a sheet of paper, attaching a translucent overlay with a pencil. This permits an inspection of the unmarked photograph and a very clear presentation of the changes which are to be made.

Tracing-type Reproduction

If a formal presentation, numerous copies and a permanent record are desired, the picture or pictures may be reproduced on photographic materials such as contact or projection type papers, sensitized tracing cloth or autopositive film or paper. When autopositive materials are used, a halftone positive intermediate gives a good quality continuous tone reproduction. Additional information may be added with a standard drawing pencil to the reproduction, and any desired number of diazo prints can be made from the reproduction, Fig. 3. These reproductions can be filed as original drawings.

The projection-type paper or sensitized cloth stands the abuse of filing, adapts to ordinary drafting technique without special white backing, and is adaptable to eradication—all desirable qualities for such service.

Some Engineering Uses

In many instances the use of still photography will reduce a long written specification to a clear concise photograph which not only requires less engineering time to prepare but can be understood more easily. Some general uses in which still photography has been used successfully are outlined below.

Relocating Existing Equipment

When preparing to move an existing installation to a new location, photographs can be made of the initial installation, and changes marked on the photographs for forwarding to the construction group.

Equipment Location

When locating new equipment in an area with existing equipment where complete drawings do not exist, a series of photographs transversing the general area can be obtained. These pictures can be used to supplement existing drawings in locating equipment and as an aid in locating tank nozzles, manholes, piping connections, pump locations, and for other purposes.

Piping Design

When it is desired to duplicate an existing piping arrangement, photographs of this installation can be made for transmitting information to the engineering and drafting groups. These pictures then can be used conveniently in discussions with operating personnel, underwriters' representatives, and others concerned.

Supplementing Field Instructions

When discussing piping changes with the operating personnel, photographs can be made as the operating personnel describe the scope of the job. The necessary piping changes can be marked on the print. The marked prints with supplementary notes can be given to the maintenance workers.

Freehand Isometric Sketches

When operating conditions make sketching at the job site impossible or impractical, freehand isometric sketches used to emphasize particulars in assembly can be made by reference to photographs of the field installation, Fig. 4.

Equipment Assembly

Equipment assembly may be presented effectively by first making a free-hand isometric sketch of the assembled unit in the center of a sheet of drawing paper. Then photographs of the component parts may be pasted around the sketch. Arrows between the pictures and the sketch may be used to indicate proper assembly.

Some of the advantages of the foregoing uses of still photography are the reduction of the number of field trips, the errors in memory, the number of verbal instructions, and the time spent in writing specifications. Information, then, is presented and transmitted with less chance of error or misinterpretation.

Still photography has been used successfully to reduce the time spent in committee meetings and conferences by allowing everyone concerned to see the existing location of equipment without making a special field trip when deciding just what equipment can be removed or

relocated in a given area. This is particularly useful when it is either too noisy or dusty to have a meeting in the allocated area. Although freehand sketches or drawings are often used for this purpose, a photograph is clearer and requires less preparation. This application of still photography has been successful in conferences with insurance representatives; safety personnel; cooperating engineers such as civil, electrical, structural, and others; immediate supervision; operating personnel or production department people; outside vendors; draftsmen; expediters; and general discussions with field construction workers. The advantages of using photographs in conferences are: (1) safety hazards are more readily spotted on pictures than either verbal explanation or drawings; (2) the number of plant trips with interested parties is reduced; (3) the number of studies or drawings or mental visualizations are reduced; and (4) the misunderstanding resulting from lengthy verbal explanations can be practically eliminated.

When underwriters, safety personnel, vendors, and other interested parties cannot be present at a field test of equipment facilities, photographs often can be taken which will supplement a repeat test or give added assurance to those concerned that the test was performed correctly and as specified.

Still photography is a great aid in covering conventions and exhibitions. The pictures can be circulated among interested engineers and any others who were unable to attend. During a lecture, graphs or charts can be photographed for immediate use where reports are not printed for publication.

Some Drafting Uses

Drafting time often can be reduced greatly by substituting a photograph for a drawing. Some applications for still photography which have successfully reduced drafting time are the following.

Reference for General Study Work

The photographs used by the engineer for equipment location also can be used by the draftsman in answering such questions as hanger location, type of hanger, pipe location, approximate pipe length, number of pieces of equipment, equipment location, nozzle location, etc.

Scale Model

Complete equipment location drawings can be made from photographs of a scale model, by taking pictures in elevation of the equipment on a model, transferring the pictures to projection-type photographic paper, sensitized tracing cloth, or autopositive film and dimensioning the reproduction, Fig. 5. It is also helpful to show a cross reference of equipment drawing numbers on this presentation for reference purposes.

Bring Files and Records Up to Date

Rather than make drafting changes to the original drawings, the records of field revisions to an existing layout can be brought up to date readily by taking photographs of the completed installation. Applications of this include the maintenance of records of exhaust and ventilation systems required by law and maintaining records for insurance companies.

Equipment Location

By taking photographs of templates located on drawing paper before they are shuffled to a new arrangement, a useful set of pictures can be obtained showing various equipment layouts. These photographs can be used in discussions with operating personnel and also can be filed for future reference.

Initiate Ideas

Filed photographs and photodrawings of existing installations often suggest ideas which can be incorporated into current designs. Such ideas might include piping arrangements, equipment supports, and structural details.

Piping Drawings

A series of photographs covering the route of the pipeline can be transferred easily to projection type paper. The resulting reproduction may take the place of cross-sections or elevation details on the piping drawings. The pipeline is then sketched in on the picture in its respective location.

Some of the general advantages of using still photography in drafting are in the reduction of field trips, isometric studies from orthographic drawings, elevation

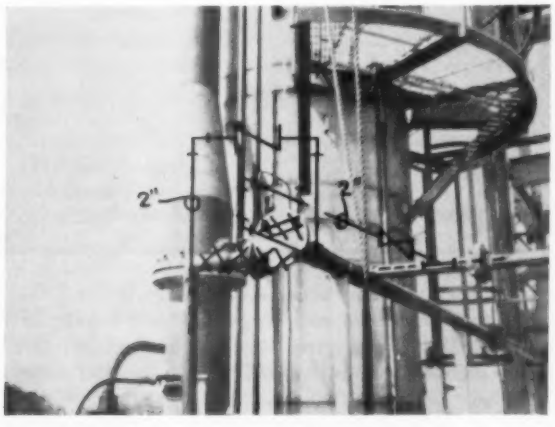


Fig. 2—(a) Picture with translucent overlay conveys the information of Fig. 1 without marking photo

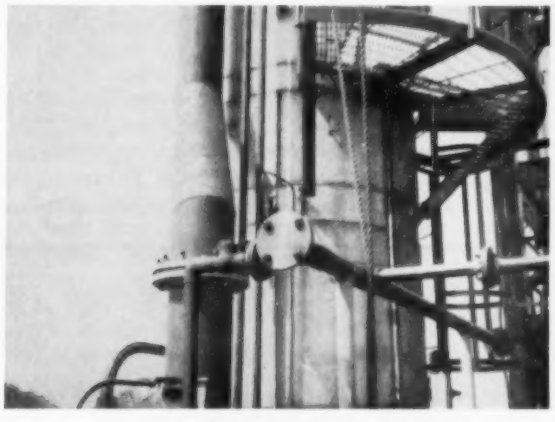
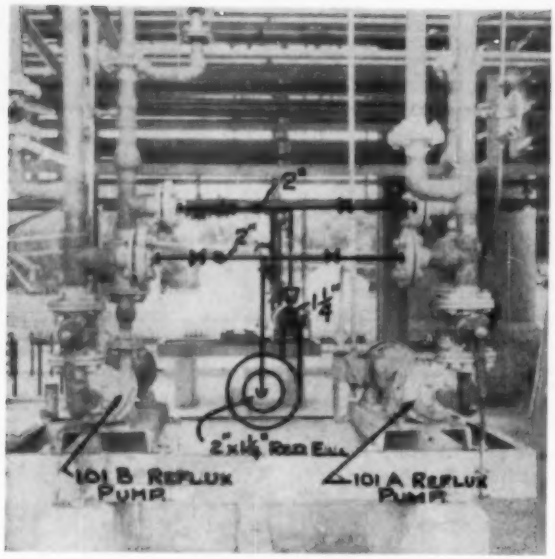


Fig. 2—(b) Picture without overlay and accompanying notes permits field crew to compare present arrangement with desired change



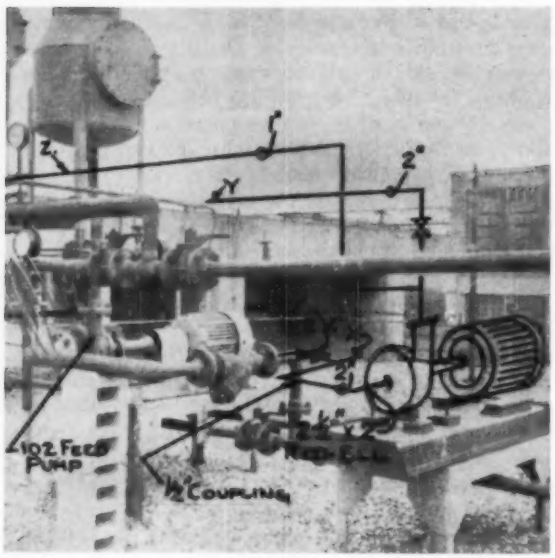


Fig. 3—Tracing type cloth for reproduction purposes. All of these views show variations of the tracing cloth for reproduction. View "A" is top, left, B, top, right

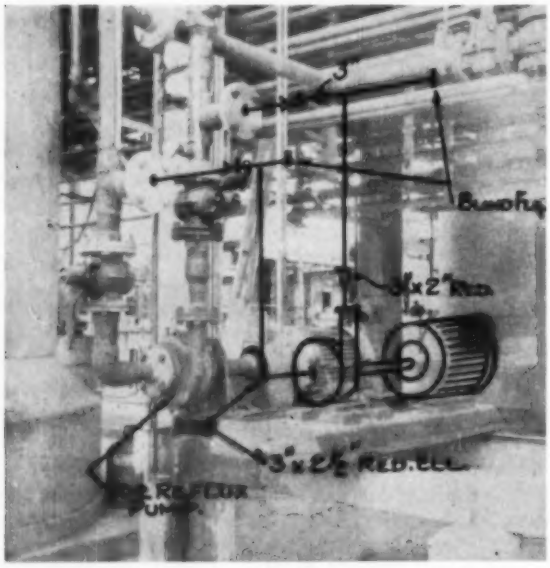


Fig. 3c—Alongside of all views, A, B, C, are instructional notes on the steps and materials in photos

Notes for View "A":
(1) Install a 1¼-in. Allis-Chalmers Type SS-SH centrifugal pump as shown between 101A and 101B reflex pumps. (See Material List 654602-3)
(2) Material of construction to be:
(a) Pipe—Copper Tubing, Type L
(b) Fittings—Mueller, solder
(c) Valves—Bronze, gate, 100 WSP, SLD, NRS, Class 34, #38

Notes for View "B":
(1) Install a 2½-in. by 2½-in. Allis-Chalmers Type SS-MH centrifugal pump as shown in View "B." (Material List 654602-5)
(2) Material of construction to be:
(a) Pipe—Copper Tubing, Type L
(b) Fittings—Mueller, solder
(c) Valves—Plug, Dezurick, Teflon seat unless noted
(3) Connect joint "Z" to a 3-in. scrubber water return line at extractor platform. At this point install a 1-in. bronze gate valve No. 40 and a blank. Steam wrap up to 1-in. valve.
(4) Connect joint "Y" to the discharge side of existing 102 feed pump. Install one 2-in. Dezurick plug valve (without Teflon seat) on top of existing pump.
(5) Connect joint "X" to the 2-in. line from the tank No. 211 and install a 2-in. Teflon Dezurick plug valve.

Notes for View "C":
(1) Install a 2½-in. by 2-in. Allis-Chalmers Type SS-MH centrifugal pump as shown in View "C." (Material List 654602-4)
(2) Material of construction to be:
(a) Pipe—Copper Tubing, Type L
(b) Fittings—Mueller, solder
(c) Valves—Bronze, gate, flange, outside screw and yoke, class 34, No. 42
(3) Install a new impeller in existing 102 reflex pump (Material List 654602-4)
(1) Remove existing 2-in. blind flange
(2) Add 2-in. piping as shown above
(3) Move 2-in. check valve to position shown
(4) Lines to be 2-in. copper with solder joint fittings
(5) New gate valve to be 2-in. bronze-solder ends

views, and explanatory notes. This results in clear drawings and lower drafting costs.

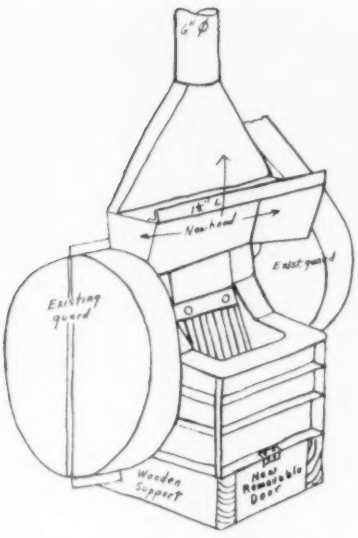
Expediters or Planners

Since an engineering release made with the use of still photography tends to be short, brief and clear, the time spent by the expediter in getting familiar with the job is below normal. This is because he can:

(1) See the full scope of the project more rapidly.

(2) Eliminate field trips because he can determine readily the necessity of scaffolding, frames, and accessibility to equipment.

(3) Rapidly explain the full scope of the project to his superiors and other interested parties.



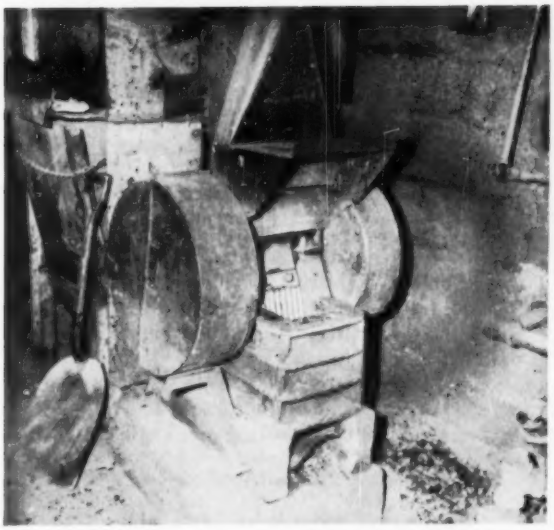


Fig. 4—Freehand isometric sketch as made from a photograph, right, allows parts to be labelled, dimensions indicated, suggested changes where photo may be too dark for suitable marking. In addition it permits observation and referral of the original areas undergoing changes

(4) Proceed more rapidly with more assurance since he need not visualize the completed project.

Construction Personnel

Experience shows that the actual field construction time can be reduced because the field workers or foreman do not have to visualize the end result from the written specification sheet or information furnished on a drawing but can quickly see the full scope of the project from the photograph. The foreman can then proceed more rapidly with greater assurance and with less chance of error. (See above under Expediters.)

Errors resulting from lengthy verbal instructions, which are sometimes forgotten or confused, can be reduced greatly by the use of the photographs.

The construction workers can explain or ask questions of their supervisors without taking them to the job site by showing the photograph and describing the problem. This reduces the time of both worker and supervisor.

Recommended Equipment

The purchase of adequate and complete equipment is of prime importance in developing the use of still photography as an engineering aid. Although there are vast assortments of photographic supplies on the market, the following is suggested as the minimum amount of equipment necessary to take satisfactory pictures:

(1) *Conventional Camera.* A camera with the following characteristics gives satisfactory results:

(a) Shutter speed ranges from approximately $^1/_5$ to $^1/_{2000}$ sec.
(b) Lens apertures from f3.5 to f32.
(c) Lens of good quality.
(d) Roll film type camera—size 620.

(2) *Polaroid Land Camera.* Where the work must proceed immediately and reprints of the picture are not necessary a Polaroid Land Camera with adequate flash attachment is useful.

(3) *Film.* A very fast, panchromatic film of moderate graininess, wide exposure and development latitude, and color sensitivity suitable for all types of indoor and outdoor illumination gives favorable results.

(4) *Light Meter.* A light meter, although not necessary, is helpful to the amateur photographer to determine exposure data.

The cost of the foregoing equipment would be in the range of $200 to $300.

Useful Tips

An efficient method of obtaining required or useful photographs would be first to photograph the entire area set aside for the project, taking as many pictures as might be of any possible use, since the cost of the photograph is minor compared to the cost of the engineering time. As the project progresses and final releases are to be made the engineer should return to take specific photographs for the final drawings or records, if necessary.

In addition to the ordinary photograph techniques used by the amateur, the engineer will find that he will obtain better results when it is necessary to use slow shutter speeds and fast film if he uses a Flexiclamp or holds his camera against a column or convenient structure or places it on some convenient available surface. He can obtain a maximum depth of field by decreasing the lens opening.

The equipment should be kept in good working order and should not be allowed to leave the plant. It is suggested that a stenographer be responsible for signing equipment in and out. If this is done, one set of the foregoing equipment can suffice for as many as 80 engineers and draftsmen. As the various techniques become accepted engineering practice, additional equipment may be justified. Experience has shown that engineers will tend to accept the use of photography as an aid in their work if equipment is readily available and simple.

Training Required

For the amateur who is already familiar with the

camera, no formal training is recommended. For others, perhaps 1 hr of instruction in the use of the camera and equipment would seem advisable. It may be desirable to shoot one roll of practice film. Those planning to use the camera within the plant should be warned of censorship and security requirements and should be given careful instructions regarding the proper care of the equipment.

Economic Limitations

Still photography is most applicable to jobs where new equipment and piping are to be installed or relocated among existing equipment. In completely new areas under development, unless shown on a model, the use of still photography is limited.

It should be recognized that sometimes the use of still photography supplements the other tools available and at other times the actual drafting and engineering time.

Other Suggested Applications

Although still photography has been used successfully in many applications, there are still many uses which are not discussed in this paper. Some of these uses are recording of vendors' testing procedures and setups, the use in conjunction with a model as a means of reducing piping drafting costs, material testing to meet required standards, a means of records for patent applications, and as a means for setting up a file for future reference on different types of successful typical installations.

Summary

Still photography has been used successfully as a means of reducing costs in engineering, drafting, expediting, and construction phases of a project. The savings result from a reduction in the number of plant trips and the simplification and clarification of drawings, written specifications and verbal instructions through the use of photographs.

Some specific engineering and drafting applications where still photography has been used successfully are in equipment location, piping design, supplementing field instructions, aid in preparing free-hand isometric sketches, equipment assembly, conferences, general study work, scale model, bringing file and records up to date, initiating ideas, and simplifying piping drawings.

It is not intended that ordinary snapshots taken by amateur photographers be used for applications requiring professional service of an industrial photography department. Certain engineering applications can be better served by a professional photographer. In most cases, however, ordinary snapshots taken by engineers or draftsmen will serve the purposes discussed in this paper.

With almost no training and with only a relatively small investment in photographic equipment, the use of still photography gives engineers a simplified means of obtaining, transmitting and recording design information. Although some initiative and perseverance are required initially, design cost savings can be realized by accepting this new technique as an engineering aid.

In order to use this application as an aid, the engineer must use imagination, and foresight in his particular work. If the engineer consciously considers photography as an aid for every project during the early establishment of this technique, the use of still photography will shortly become an accepted engineering practice.

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Industry Seminar Planned Electrostatic Precipitation

A seminar of interest to engineers in public utilities and in various industries who are concerned with the installation and operation of electrical precipitation equipment will be held June 9 to 13 at The Pennsylvania State University.

Ralph E. Armington, associate professor of electrical engineering at Penn State is chairman of the seminar. The first day and a half will be devoted to the principles underlying the electrical precipitation process, and will be presented by Dr. H. J. White, director of research, Research-Cottrell, Inc.

The remainder of the week will be devoted to precipitator applications with particular reference to public utilities. There will also be discussion of the problems of energization and measurements.

Seminar participants will be divided on three afternoons into smaller special interest groups to discuss specific problems in precipitation, accompanied by one or more qualified "resource persons."

Inquiries should be addressed to the Extension Conference Center, The Pennsylvania State University, University Park, Pa.

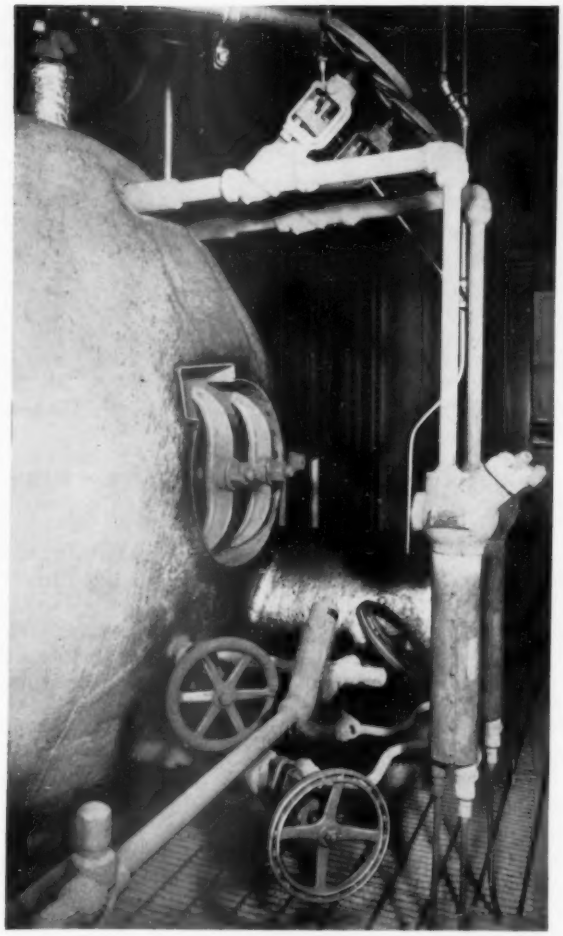

Fig. 1—Photo showing a few of the many Welbond Valves used around a high pressure boiler on the West Coast

High Pressure Valves for High Temperature Duty

At present the need for high pressure valves for the sub-critical and some supercritical pressure boilers going into service seems confined to instrument and currently drain requirements. Here is an excellent report by a valve manufacturer on their developments for valves up to 2½ in size.

By RICHARD A. HANDSCHUMACHER, M.E.*

Yarnall-Waring Company

THE constant rise in boiler operating pressures and temperatures in recent years has presented a series of design problems to builders of boiler auxiliary equipment. One of the problems faced by both operators and manufacturers is that of maintaining small valves, up to $2^1/_2$ in., used on and around high pressure boilers. The solutions to this problem should be of interest and value to all plant designers, operators and equipment builders.

Design Essentials

Prevention of leakage is the ideal of all designers and builders of small valves for high pressure boilers. Other important factors include choice of suitable materials and accessibility for maintenance. Still another factor is whether to sacrifice the desirable design feature of accessibility in order to include the features of a back-seated valve.

Small valves may leak at one or more of three places:

1. At the seal between the body and the bonnet.
2. Through the valve seat.
3. Through the stuffing box.

In high pressure-high temperature service, leaks at any of these points can cause serious hazards to personnel and be wasteful of fuel.

For high temperature and pressure applications, the bolted bonnet valves using gasketed joints are being supplemented by the integral bonnet design.

Today, all better grade valves for these services are made with an integral body welded to, or made in one piece with, the bonnet (integral bonnet or integral body and yoke type). These types of construction (Fig. 2), by eliminating the seal between the body and bonnet, automatically solve problem No. 1.

To eliminate leakage through the seat, most modern high pressure valves are of the globe type, built with integral stellited seats (Fig. 3) instead of the screwed-in seat rings formerly used. This prevents leakage through the seat threads and radically reduces cutting of the valve seats and disks.

Stuffing box leakage is still somewhat of a problem, but to a great extent it has been overcome by the proper matching of approved ring packing with a corrosion resistant steel valve stem. A form of "loose"

* Manager of Engineering Department

Fig. 2—Three designs of modern welded bonnet valves with welding ends (a), left, shows "loose" backseating; (b), middle, "rigid"; (c), inhibited ring packing

(Fig. 2(*a*)) or "rigid" (Fig. 2(*b*)) back-seating is provided by some manufacturers to provide protection for their packing and stem material in this area when the valve is in the open position. The Welbond Valve (Fig. 2(*c*)) using an inhibited ring packing, together with type 321 stainless steel, has greatly reduced corrosion of valve stems and the resulting packing leaks.

Elimination of the need for valve stem packing is the goal of all enlightened valve manufacturers. This has been accomplished in some low pressure valves but still remains to be solved in valves for use in high pressures and temperatures.

Valve Uses

Typical uses include the following services:

- Water wall and economizer drains
- Drum and superheater vents
- Water column and steam gage emergency shut-off
- Stop and bypass valves on continuous blowdown lines
- Steam and water sampling
- Desuperheater sprays and strainer blowoffs
- Stop drains and vents on instruments and other small service lines.

It will be noted that most of the typical uses are for "dead-end" or periodic blowdown service on which the pressure is perferably under the disk with the valve normally closed. Boiler shutdowns are minimized by double valving those small lines in which excessive leakage of a valve would be objectionable.

Thus, the failure of a small valve can hamper boiler operation or even cause a shutdown. It is for this reason that valve design, selection, installation, operation and maintenance are important to all operators of high pressure plants today. These factors are discussed in the remaining portions of this article.

Typical Designs

Fig. 2 shows three typical high pressure valves, there are, however, other manufacturers who provide variations of these designs.

When boiler pressures were in the 400 to 600 psi class and screwed-in seat rings were standard practice, leakage around the stem was common, so it became imperative in some installations to make provision for repacking the valve while it was under pressure. An entirely different condition exists today in many plants, for with operating pressures of 1500, 2500 and higher, the safety of operating personnel becomes an important factor.

Since many valves are used in the normally closed position with pressure under the seat repacking under pressure is not a problem as the packing is not under high pressure. Under these conditions the accessible feature of a non-backseated valve design has been found most acceptable and simplifies the servicing procedure when inspection or repair of the internal parts is required.

In those installations where the valve is normally open and the packing can be subject to high pressure, present practice prohibits repacking under pressure because of the hazard, some plants have found it necessary to provide some form of backseating to minimize the hazard, caused by leakage, to unauthorized personnel who may attempt to repack a valve under high pressure.

The "rigid" backseating gives a higher degree of protection under these conditions than the "loose" type, however, either arrangement usually creates some difficulties for the authorized mechanic when the valve needs servicing.

The packing in valves of this type should not require attention between annual shutdowns aside from occasional tightening of the gland bolts.

Valve Design Requirements

Ventilated handwheel: Since valves around boilers are often in hot areas, it is essential that the handle not overheat. Otherwise, operating personnel may suffer burns when using the handwheel. H-section handwheels, Fig. 4(*a*), give good service because they have large ventilated openings. These insure a cool handle under the most adverse operating conditions. If desired, T-type handle can be substituted for the round wheel similar to that shown in Fig. 2(*b*).

Accessibility for maintenance: Internal parts of high-pressure valves must be readily accessible for inspection and maintenance. If these parts are difficult to get at, maintenance may be neglected, leading to costly troubles. It is not uncommon for valves, whose internal parts are not accessible, to be cut out of the line and replaced by a spare, while repairs are made in the maintenance shop.

The valve shown on Fig. 2(*c*) is arranged so all working parts can be removed through the top of the yoke. Once these parts are taken out, the integral stellite seat is easily reached. After loosening the gland and re-

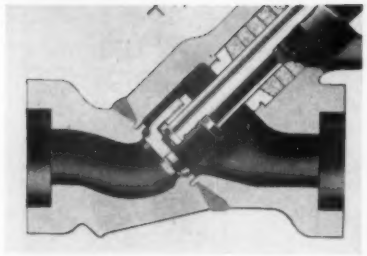

Fig. 3—Integral stellite seat for the valve in Fig. 2(c). Disk is stellite-faced and free to turn on the stem for accurate seating

Fig. 4—Ventilated H-section handwheel for welded-bonnet valve is shown at (a)., above

Fig. 4b, above, is the seat nozzle ready for welding to the valve body and section of seat nozzle welded in place on the valve body

moving its split bushing, the packing is removed by jack action of the stem. Then the tack weld of the yoke bushing is broken, the bushing backed out and the stem, packing and disk removed through the top of the yoke.

Body and yoke: Since these valves are used in high-temperature service, it is important that no distortion of the valve take place at its maximum operating temperature. A solution to this problem is the one-piece body and yoke, Fig. 4(*b*). The seat nozzle is welded to the valve body to provide a single assembly that will not distort and provide a positive seal with the disk. Most modern valves have smooth inner surfaces and streamlined contours to reduce turbulence and the pressure loss during flow of steam through the valve, Fig. 2.

Valve stem and disk: To insure accurate seating of the disk when the valve is closed, the stem must be properly guided. In the design shown in Fig. 2(*c*), the stem is guided by bushings in the yoke, gland and stuffing box. The stem in most valves for high-temperature service is fitted with an extra long shank so the threaded section is not exposed to the high temperature. As pressures continue to climb it may be necessary to provide a non-revolving stem in the packing area.

To resist distortion and cutting from the effects of high-temperature steam, small valves around high pressure boilers are fitted with a stellite-faced disk. Attached to the stem to prevent loosening by tack welding to disk nut, the disk has a slight play to permit self-aligning and tight seating without wear of the mating parts.

Valve seat: The valve seat, too, must resist distortion if reliable service is to be expected. Different methods are used to secure freedom from distortion, excessive wear and leakage. The design in Fig. 4(*b*) uses an integral stellite seat welded to the seat nozzle. The nozzle, in turn, is welded to the body. An annular groove around the seat prevents distortion during assembly welding and in operation gives accurate seating for a positive seal when the valve is closed.

Yoke construction: Fig. 5 shows how the use of a smooth contoured yoke section combined with a slight bowing of the ribs can materially reduce the stresses. The slight bowing of the ribs (sometimes referred to as a "compensating yoke") acts as a safety feature in that it permits excessive loads to be absorbed by movement of the ribs, within the elastic limit of the material, without distortion. This feature tends to act as a spring when the valve is closed and helps to maintain a tight seal between the seat and disk.

Valve Materials

The design in Fig. 2(*c*) is built in sizes ranging from $^1/_4$-in. to 2-in. for all services in the 1500 psi rating including straightway and angle patterns, with socket-welding ends. Table I lists the materials used in 1500 and 2500 psi rated welded-bonnet valves of this design.

The valves similar to the one shown in Fig. 2(*c*) are built for a basic 1500 psi rating at temperatures up to 1050 F in steam service. In waterwall and economizer drain service the maximum allowable pressure is 3060 psi at 700 F.

The 2500 psi standard design shown in Fig. 2(*c*) is available in sizes from $^1/_4$ in. to $2^1/_2$ in. Suitable for temperatures up to 1050 F. in steam service, this valve may be used at pressures up to 5105 psi in waterwall and economizer drain service when the temperature does not exceed 700 F and frequent operation is not required of the revolving stem.

Since these valves are basically designed for high pressure-temperature service, many of the manufacturers use a chrome-moly material as standard, which enables direct shipment from stock and simplifies the manufacturing and inventory problems.

Valve Selection

Fig. 6 and Table II are useful in choosing valves (Design 2(*c*)) for high pressure boiler service. When choosing valves of this type be sure that they conform to the ASME Boiler Code.

It will be noted that the valve temperature-pressure ratings will not always agree with those published by A.S.A. (American Standards Assn.) since the ASME Code permits each manufacturer to design his valve in accordance with the allowable stress of the material used. Each valve manufacturer is responsible for his design to insure that such areas as the body thicknesses are within the allowable stress levels.

To use Fig. 6, determine (1) the service for which the valve is to be used, (2) the maximum temperature of the fluid expected in service, and (3) the maximum pressure expected in service.

Example: What is the maximum allowable pressure for a 1500 psi rating welded-bonnet valve handling 1000 F steam?

Fig. 5—Yoke stress patterns using the brittle lacquer technique under equal loads before and after introduction of a smooth contoured yoke section with a slight bow to the yoke ribs to reduce stresses. This allows the ribs through their movement to absorb some extra load.

Solution: Enter the bottom of Fig. 6 at 1000 F and project vertically to the 1500 psi valve curve. At the left read the maximum allowable steam pressure that the valve can handle at this temperature as 2020 psi.

Example: Can a 1500 psi valve be used for 3000 psi economizer drain service at saturation temperatures (695 F)?

Solution: Enter Fig. 6 at the side at 3000 psi and project horizontally sidewards to the 1500 psi valve curve. At the bottom read the allowable temperature as approximately 750 F, which is above the saturated steam temperature, indicating that the 1500 psi valve can be used.

The valves in Fig. 6 are used in the same manner for 2500 psi valves. By entering Fig. 6 at the working pressure on the left and projecting to the correct valve curve, the allowable working temperature can be determined or vice versa.

Example: A 2500 psi rated valve is to be used in steam service (for infrequent operation) at 4660 psi. What is the allowable working temperature of the steam?

Solution: Enter Fig. 6 at the left at 4660 psi and project horizontally to the right until the 2500 psi valve curve is intersected. At the bottom of the chart read the maximum allowable steam temperature as 850 F.

When the pressure rating of the valve to be used is not known, enter the chart with the working pressure and working temperature and project from both values until the point of intersection is obtained on the chart. If this point lies below the 1500 psi curve, then a 1500 psi valve is suitable. If the point lies between the 1500 and 2500 psi curves, use a 2500 psi valve. If the point is above the 2500 psi curve, consult the manufacturer.

Example: What class valve must be used for 2000 psi and 900 F steam service? What class valve must be used for 3000 psi and 1000 F steam service?

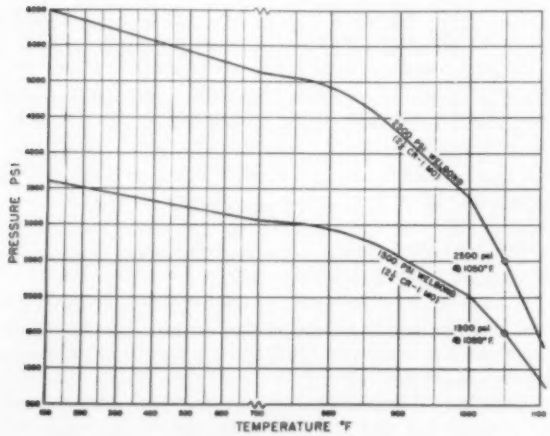

Fig. 6—Selection chart for design welded-bonnet valves

TABLE 1—MATERIALS USED IN CONSTRUCTION OF A WELDED-BONNET TYPE STEAM VALVE

Parts Name	Materials	Specifications
Body	Chrome-Moly steel	A-217-WC9
Nozzle (stwy valve)	Chrome-Moly steel (integral stellite seat)	A-217-WC9
Gland	Chrome-Moly steel	A-217-WC6
Split gland bushing	Stainless steel	Type 416
Disk	Chrome-Moly steel (stellite seating face)	A-182-F22
Disk nut	Stainless steel	Type 410
Stuffing box bushing	Nickel alloy	. . .
Yoke bushing	Hard duronze	. . .
Stem	Stainless steel	Type 321
Handwheel	Malleable iron	A-47-32510
Hex nut	Steel	A-194-2H
Hex nuts	Steel	A-194-2H
Gland bolts	Steel	A-193-B7
Disk insert	Stainless steel (heat treated)	Type 420
Packing	Jacketed type asbestos	Wire reinforced

TABLE II—SELECTION TABLE FOR 1500 AND 2500 PSI YARWAY WELBOND VALVES
(FIG. 2(*c*) DESIGN)

Service Temp., °F	Temperature-Pressure Ratings of Yarway Welbond Valves — Maximum allowable pressure psi, for 2¼ CR-1 MO valves — 1500 psi valves: Yarway Welbond	1500 psi valves: A.S.A. Rating	2500 psi valves: Yarway Welbond	2500 psi valves: A.S.A. Rating
100	3600	3600	6000	6000
150	3555	3550	5925	5915
200	3510	3500	5850	5830
250	3465	3450	5775	5750
300	3420	3415	5700	5690
350	3375	3375	5625	5625
400	3330	3330	5550	5550
450	3285	3255	5475	5430
500	3240	3125	5400	5210
550	3195	2955	5330	4925
600	3150	2770	5255	4620
650	3105	2580	5180	4300
700	3060	2415	5105	4025
750	3015	2250	5030	3745
800	2950	2080	4920	3470
850	2795	1915	4660	3190
875	2680	1830	4465	3055
900	2560	1750	4275	2915
925	2425	1665	4045	2775
950	2290	1585	3820	2640
975	2155	1500	3590	2500
1000	2020	1335	3360	2230
1025	1760	1165	2930	1945
1050	1500	995	2500	1655
1075	1175	855	1960	1430
1100	855	720	1425	1200

Solution: Enter the chart on the left at 2000 psi and project horizontally to the right until the 900 F ordinate is intersected. Since this point lies below the 1500 psi curve, a valve rated at 1500 psi should be used. Following the same procedure for the 3000 psi, 1000 F application shows that a valve with 2500 psi rating should be used.

Table II permits easy determination of the allowable pressure rating and ASA rating for valves (Fig. 2(*c*) Design) at various temperatures. The table is used when the operating temperature expected is one of the values tabulated. If the temperature is not tabulated, use Fig. 6 on the facing page.

Locking Devices

Straightway design welded-bonnet valves can be used for shutoff service between the boiler drum and water gage, as well as on the steam-gage lines. For water column and steam-gage service the valves shall be fitted with a locking arm and padlock. This provides both the required lock-open device and indicator to show whether the valve is in the open or closed position. Fitted this way, the welded-bonnet valve fully meets the requirements of the *ASME Boiler Code*. In an emergency, the locking device can be freed by a blow.

Installation and Maintenance

Piping adjacent to the valve should be supported in a manner to keep the thrust and bending moment on the valve to a minimum. Follow the recommendations in Section 6 of the *ASA Code for Pressure Piping* when installing piping and valve supports.

Valve stems should be lubricated at regular intervals with superheat mineral oil.

If a valve is opened up to check the disk and seat during the annual boiler shutdown, the stem packing should be replaced. Jacketed asbestos packing, especially selected for use with austenitic stainless steel stems, is used in high-pressure-high-temperature service.

Conclusions

Small welded-bonnet valves are popular for steam and feed services around high-pressure boilers. For best results in service, these valves should be specifically designed for the conditions anticipated. A number of different designs are currently available.

Choose small welded-bonnet valves only after the class of service, operating pressure and operating temperature are known. Use the data provided by the manufacturer when deciding pressure class to use.

Maintain the valves regularly. Inspect annually.

Welding Engineers to Meet

Ninety-five authors will present 63 papers at the annual National Spring Meeting of the American Welding Society. The meeting will be held in St. Louis in conjunction with the sixth Welding Show, April 15 to 17 inclusive at the Kiel Auditorium,in St. Louis, while the five-day technical sessions will be presented at the Hotel Statler April 14 through 18, inclusive.

Twenty-one sessions covering various aspects of welding will be conducted, with three papers read at each. Four of the sessions will be co-sponsored by the metals engineering division of the American Society of Mechanical Engineers.

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By B. L. CANADAY

Dowell Incorporated

The in-place washing of regenerative air preheaters has proved an effective means of combatting the build-up of soluble deposits at the cold end of these units. Now a system of jet cleaning with water at pressures up to 3000 psi has been employed successfully in removing soluble and insoluble deposits.

High-Pressure Jetting of Regenerative Air Preheaters

AN effective method has been found for removing insoluble deposits from preheater elements. This cleaning method uses jets of water at pressures up to 3000 pounds to remove scale hydraulically.

Preheaters increase boiler efficiency by removing heat from furnace exhaust gases and using it to preheat air entering the furnace's combustion chamber. There are three major types of air preheaters, plate, tubular, and regenerative. Regenerative preheaters are now most widely used in power plant designs.

A regenerative heater consists of a shaft, usually vertical, around which the rotor (a cylindrical mass of heat-transfer elements) turns. The heat-transfer elements are a honeycomb of vertical passages made of corrugated sheet metal. The rotor is mounted between two ducts, with about half of its area in each. One duct carries hot exhaust gases from the furnace, while the other brings incoming air to the furnace combustion chamber. The constantly turning rotor is continuously heated and cooled by the exhaust gases and air as it transfers heat from the gases in one duct to the air in the other.

The physical size of a regenerative heater varies according to the capacity of the generating unit. A typical preheater for a million-pound-per-hour boiler would have a rotor mass 20 ft in diameter and 6 ft high. Vertically, there are usually three layers of sheet-metal elements. The cold-end elements (baskets) can be removed for cleaning in an orderly fashion.

When the preheater is in operation, particles from the exhaust gases are deposited on the metal elements, plugging them and closing off their passages. These deposits reduce flow and increase pressure losses.

Preheater Deposits

Such deposits are of two main types. The first is a highly-soluble deposit which accumulates largely at the cold end of the rotor. Most of these deposits can be washed away, leaving only small amounts of insoluble material on the surfaces of elements. However, when the heater is returned to service, these residual deposits bake onto element surfaces and become even more difficult to remove. After repeated washings, such accumulations of insoluble deposits create a serious problem.

The other type of deposit consists of slag and refractory material carried from superheater and reheater sections of the steam generator into the hot end of the preheater elements. These particles break into small pieces, lodging within passages of hot end elements and restricting passage of finer flue dust particles through the preheater. This type of deposit cannot be removed satisfactorily by conventional washing methods.

In the past, it has been necessary to disassemble and scrape by hand heat-transfer elements which did not respond to water washing, or to replace them with new elements. Either procedure would keep boilers out of

TABLE 1—Test Data

Description of sample: brown and tan colored, brittle pieces two to three millimeters thick
Preliminary tests: no effervescence in acid
Qualitative: contains iron oxide, silicates, and sulfur compounds
Qualitative: SiO_2, 29%

Test No.	Sample Wt., G.	Solvent: Amount, Cu Cm	Solvent: Type	Temperature, F	Time, Hr	Concentration of Used Solvent, %	Wt. of Residue, G	Cumulative % of Original Sample Dissolved
1	3.50	77	5% HCl	150	2	4.4	2.75	21
11	4.12	82	5% HCl	110	2	4.8	...	
11a	Residue from Test 11	100	2% soda ash	110	2	...	3.18	23
11b	Residue from Test 11a	64	5% HCl	110	2	4.8	2.90	30
11c	Residue from Test 11b	100	2% soda ash	110	2	...	2.75	33

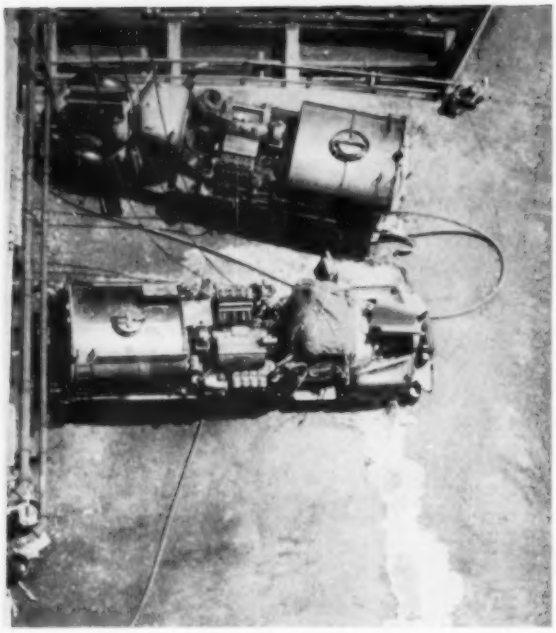


Fig. 1—Positive displacement, triplex pumps capable of delivering 75 gpm at 3000 psi are truck-mounted for flexibility

TABLE 2

Ohio Power Company, Tidd Plant
Unit No. 2 Air Preheater Performance

Tabulated below are a series of readings obtained in order to determine air and draft losses of Boiler No. 21, before and after the most recent cleaning.

Date →	9/25/53	10/26/53	2/24/54	3/12/54	6/16/54	8/25/54
Air flow	1050	1030	920	925	995	1060
Steam flow	1140	1110	930	865	1025	1135
Excess air, %	...	8	17	14	15	9
F.D. fan outlet, in. water	11.6	11.3	12.0	9.1	12.0	8.0
Secondary air, in. water	2.3	2.5	2.0	2.7	3.2	2.3
Econ. outlet, in. water	5.8	5.7	4.5	4.3	5.0	5.3
Air htr. outlet, in. water	11.5	11.5	11.5	8.9	11.2	10.0
I.D. suction, N., in. water	16.0	15.6	14.3	11.0	14.1	13.2
I.D. suction, S., in. water	16.3	15.9	14.8	10.9	13.7	12.6
N. ash hopper loss, in. water	4.5	4.1	2.8	2.1	2.9	3.2
S. ash hopper loss, in. water	4.8	4.4	3.3	2.0	2.5	2.6
Prehtr. gas press. loss in. water	5.7	5.8	7.0	4.6	6.2	4.7
Prehtr. air press. loss, in. water	9.3	8.8	10.0	6.3	8 8	5.7
Expected air press. loss, in. water	5.9	5.7	4.8	4.9	5.4	6.1

The following comments are those of an Ohio Power Company Results Engineer:

"In one manner of speaking, we might say that the last set of readings is a termination of a problem which has been with us for several years. Cleanliness was restored to a condition more than equal to that existing at the start of 1949. We do not yet know all the answers in regard to the cause of our serious preheater fouling, but we do have a method of washing which will successfully clean it. With this in mind, two curve sheets are attached which illustrate the rate and degree of fouling and the effect of washing, from early in 1949 to the present. These curve sheets tell the story, I believe, much better than any words I might use."

operation so that a scheduled outage time was needed.

In 1943 an effort was made at one plant to remove these non-soluble deposits by chemical action. Data Table No. 1 gives the results of a chemical analysis of the deposits. As the table shows, when the deposits were insoluble in water, they were also relatively insoluble in acid.

The removable portions of the elements were placed in a vat. Alternate stages of acid and soda ash were then applied to the elements until they were clean. While the treatment cleaned these portions of the elements successfully, it was expensive and slow, and did not clean the elements which could not be removed from the rotor.

Jet Cleaning

In 1954 a new cleaning method employing high velocity jets of water was applied to the problem of cleaning Ljungstrom air preheaters. Water pressure for the cleaning treatments was furnished by mobile, high pressure pumps. These positive displacement, triplex units are designed to deliver 75 gpm at 3000 pounds pressure. Fig. 1 shows two of these truck-mounted pumps in position, ready to begin a cleaning treatment. In order to maintain maximum pressure, water from the 2-in. pump discharge was divided between two 1-in. hoses. These streams were then split into four $^1/_2$-in. hoses near the jet head.

Sixteen specially developed, tapered jets were mounted in the jet head. They are designed to produce minimum turbulence in the jet stream in order to make efficient use of pumping energy. Their $^1/_{16}$-in. openings will pass 4 gpm at 3000 pounds pressure, and will hold a stream together more than 15 ft through the air.

Usually, two of these jet head assemblies were used in the cleaning treatments, one mounted beneath the preheater unit, and the other mounted above it. Photograph No. 2 shows a jet head mounted beneath the heat-transfer elements. The mounts to which the jet heads are attached have roller bearings which run along U-channel beams. The jet heads are positioned along the beams by means of screw rods. The screw rod cannot be seen in Fig. 2, but one is shown in Fig. 3. Here the upper jet head is in position to begin the cleaning treatment.

The details of mounting the U-beam vary in different installations. In general, it is positioned so that it runs from the rotor hub outward, allowing the cleaning head to traverse the full radius of the rotor. It must be solidly attached in order to withstand the reaction forces of the jets. So that the streams from the two jet heads will not oppose each other, either the positions of the mounts must be staggered, or the jet heads must be placed so that they are working on different radii. The rotor must turn continuously during the cleaning treatment so that the 16 jets can penetrate all of the small passages in the elements as they pass by.

The treatments usually started at the rotor's outer edge. The jet heads were positioned and the rotor was started at about $^1/_{15}$ rpm. The jet heads were left in this position until the rotor had made three complete revolutions. Then they were moved the width of the jet head closer to the hub. This procedure was repeated until the outside two feet of the rotor had been cleaned.

The rotor's velocity was then increased to $^1/_{10}$ rpm. The shorter radius near the rotor's hub where the jet heads were then working gave them more cleaning time through each passage. Also, there was usually less fouling material deposited there. Therefore, it was possible to increase the speed of the rotor and still maintain proper cleaning action. (See p. 58 for Figs. 4,5,6,7 on Procedures).

When the next two feet of the rotor's radius had been cleaned, the jets were allowed to work for only two revolutions of the rotor. When the outer six feet of the rotor's

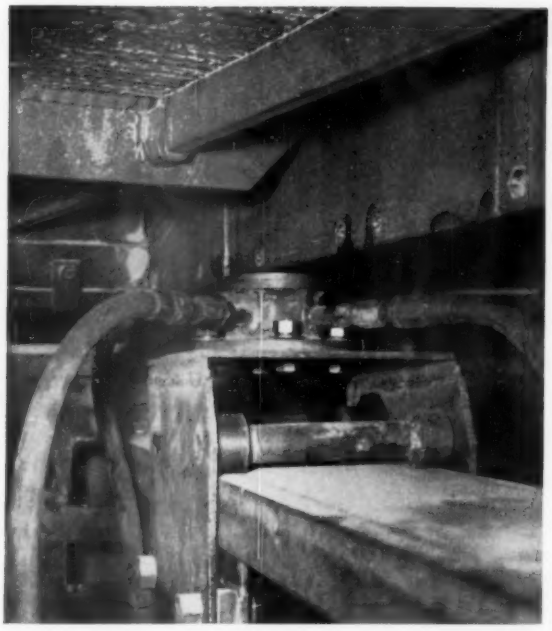


Fig. 2—Special jet head is shown mounted beneath the heater elements. Note the different supply hosing

Fig. 3—A screw rod in the U-channel beam above the jet head support permits positioning the jet with respect to the heater

ten-foot radius had been cleaned, the speed of rotation was increased to $^1/_7$ rpm, and the rest of the heater was given only one pass. The rotor was then inspected, and if any areas still contained fouling material, they were further treated until they were clean.

Fig. 4, 5 and 6 show progressive steps in the cleaning treatment. In Fig. 4, loose, powdery material is being blown about at the start of operations. Pressure here was approaching 2000 psi. In Fig. 5, the rotor has made one revolution while water pressure and rotor speed were adjusted. The pressure is now 2800 psi. In Fig. 6, the jet assembly has worked in the first swath during two revolutions of the rotor, at 2800 psi, and has been moved into the second swath. Part of the jet stream from the bottom jet assembly is coming through all the elements and striking one of the high pressure hoses.

Fig. 7 gives a closeup view of the first cleaning swath in the top element after two revolutions have been completed. The severe plugging of the uncleaned part of the element can be seen in sharp contrast to the cleaned portion. P. 58 shows the Procedures in step form.

Cleaning Results

The cleanness of the elements could be estimated at any time during the cleaning by observing the jet stream. When the elements were clean, the lower jet completely penetrated them, and could be seen emerging at the top. The action of the upper jet head could be observed from either the top or the bottom. If the passages were stopped, the jet streams did not completely penetrate them. When the passages were open, the streams passed through, Fig. 6, p. 58.

The best inspection method during the actual cleaning was to view a light through the rotor. After the first pass over a swath, light showed through in spots. After the third pass, practically all of the passages were clear. By the fourth pass, only an occasional passage showed any blockage.

Experience has shown that cleaning treatments can be carried out more quickly when the unit has been washed with low-pressure water streams, thoroughly wetting the deposits, before the treatment begins. It has also been found that the use of surface-tension-reducing agents materially decreases the cleaning time. The acid which is generated when water contacts the scale can be neutralized by an alkaline solution.

Detailed data on the results obtained by this cleaning method are given in Data Tables 2, 3 and 4. The data shown are furnished through the courtesy of the company named in each data table heading.

TABLE 3

Baltimore Gas and Electric Company
Gould Street Station
Boiler No. 3

East preheater cleaned by high pressure jetting from top only.
West preheater cleaned in normal manner (low pressure water from top only).

Pressure Drop Across Preheaters

	East	West
Before cleaning	4.3 in. water	4.0 in. water
After cleaning	3.7 in. water	3.8 in. water

East and west preheater cleaned by high pressure jetting from top and bottom.

Before cleaning	3.9 in. water	4.1 in. water
After cleaning	3.2 in. water	3.5 in. water

TABLE 4

Public Service Electric and Gas Company, New Jersey
Kearny Generating Station

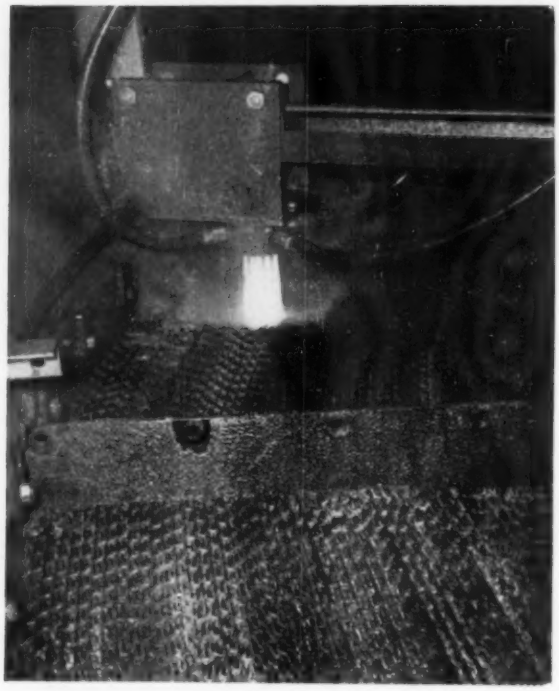
Weight of basket before jetting and weight of basket after jetting showed following:

No. 1—86 pounds of dirt removed
No. 2—66 pounds of dirt removed
No. 3—97 pounds of dirt removed
No. 4—81 pounds of dirt removed

Based on basket No. 2 this would be about 6 tons of dirt removed per set of heaters.

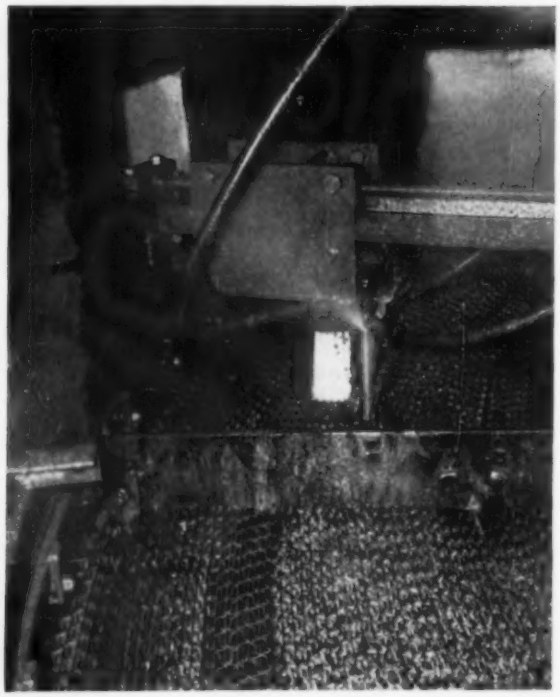
Progressive Steps in Jet Cleaning Go Like This . . . . . .

4. Loose, powdery material surrenders to a 2000 psi blast and is blown free . . . . . .

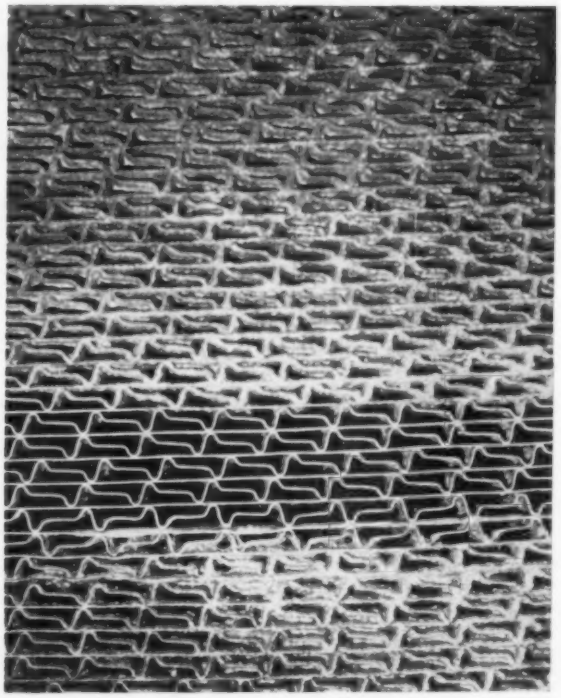


5. Water pressure and rotor speed have been picked up. Pressure is now at 2800 psi . . . . . .

6. Two revolutions have been completed and elements are so clean bottom jet stream blows through . . .



7. Contrast between cleaned and uncleaned elements shows clearly in closeup below . . . . . .



American Power Conference Program

THE twentieth annual meeting of the American Power Conference will be held on March 26, 27 and 28 at the Sherman Hotel in Chicago.

The Conference is sponsored by Illinois Institute of Technology in cooperation with fourteen leading universities and ten national and regional societies throughout the United States.

Wednesday, March 26, 1958 9:00 a.m. Registration

10:00 a.m.–12:00 Noon. Opening Meeting

12:15 p.m. Joint APC-ASME Luncheon. Sponsored by American Society of Mechanical Engineers

Chairman: James N. Landis, President, ASME.

Co-Chairman: E. P. Berg, Chairman, Chicago Section ASME.

Speaker: J. W. McAfee, President, Union Electric Company of Missouri.

2:00–5:00 p.m. Steam Turbines Sponsored by Power Division of ASME

Chairman: W. E. Hopkins, Chairman, Power Division ASME and Mechanical Engineer, Stone and Webster Engineering Corp.

Co-Chairman: R. Clay Porter, Professor of Mechanical Engineering, University of Michigan.

"Steam Turbines for Nuclear Power Plants," by J. A. Carlson, Supervising Engineer, Large Turbine Engineering Department, Westinghouse Electric Corporation, Philadelphia, Pa.

"High Temperature Steam Turbine Design Improvements from Operating Experience," by E. P. Hansen, Assistant Chief Engineer, A. C. Holmes, Engineer in Charge, Steam Design and J. J. Fleischmann, Supervisory Engineer, Mechanical Design, Steam Turbine Department, Allis-Chalmers Mfg.

"Turbine Generators for the '60's," by C. E. Kilbourne, Manager, Product Planning and Marketing Research and C. W. Elston, Manager, Turbine Engineering, Large Steam Turbine Generator Department, General Electric Co.

2:00–5:00 p.m. Water Technology I—Panel Discussion on Deaeration

Chairman: S. F. Whirl, Chemical Operating Engineer, Duquesne Light Co., Pittsburgh, Pa., and Past Chairman, Executive Committee, Engineers Society of Western Pennsylvania.

Co-Chairman: T. J. Hodan, Manager, Water Conditioning Section, Allis-Chalmers Mfg. Co.

"Deaerators—Manufacturers' Viewpoint," by Ralph M. Lemen, The Permutit Co.

"Condenser Hotwells—Manufacturers' Viewpoint," by R. A. Wilson, Allis-Chalmers Mfg. Co.

"Deaeration—Boiler Manufacturers' Viewpoint," by H. A. Grabowski, Combustion Engineering Co.

"Deaerators—Operator's Viewpoint," John R. Bryant, Union Electric Co.

"Condenser Hotwells—Operator's Viewpoint," by A. M. Guy, Southern Indiana Gas and Electric Co.

"Deaeration—Design Engineer's Viewpoint," by W. R. Steur, Sargent & Lundy.

2:00–5:00 p.m. Heating, Ventilation and Air Conditioning. Sponsored by the Heating and Air Conditioning Division, Chicago Section, ASME

Chairman: E. P. Berg, Chairman, Chicago Section, ASME.

Co-Chairman: Howell J. Holloman, Mechanical Engineer, Ragnar Benson.

"Ventilation of Research Nuclear Reactors," by John Dolio, Partner, Shaw, Metz and Dolio.

"The Multistage Heat Pump and Its Applications," by Robert G. Werden, General Sales Manager, Engineered Machinery Division, York Corp.

"Central Station Ventilation," by Robert W. Patterson, Sargent and Lundy.

7:30–10:00 p.m. Evening Forum

A progress report on nuclear developments in the electric power industry. Executives of a number of electric utility companies will describe the current status of the various nuclear reactor projects in which they participate.

Thursday, March 27, 1958 9:00 a.m.–12:00 Noon. Central Stations I

Co-Chairman: H. L. Solberg, Head, School of Mechanical Engineering, Purdue University, Lafayette, Ind.

"Operating Experience with the First Commercial Supercritical Pressure Steam-Electric Generating Unit at the Philo Plant," by T. T. Frankenberg, A. G. Lloyd and E. B. Morris, American Gas and Electric Service Corp.

"Operating Experience with the First Commercial Universal Pressure Steam Generator at Philo," by J. D. Andrews, Jr., and P. H. Koch, Application Engineers, and E. A. Pirsh, Staff Engineer, Babcock and Wilcox Co.

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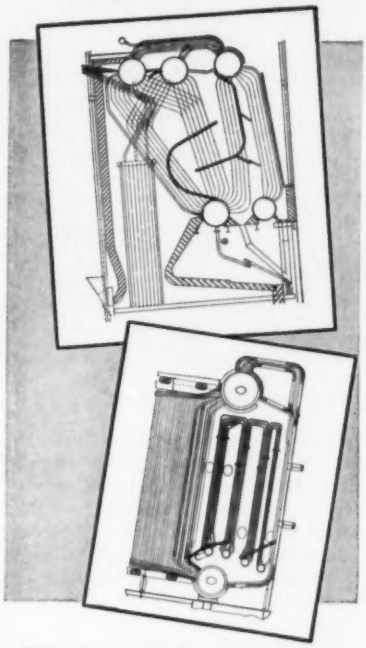

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9:00 a.m.–12:00 Noon. Fuels. Sponsored by the Fuels Division of ASME

Chairman: Vaughn Mansfield, Chief Engineer, Peabody Coal Co.

"Energy Aspects of Underground Gasification Processes," by Coultas D. Pears, Head of Analysis and Measurement Section, Engineering Dept., Southern Research Institute; John Capp, Acting Superintendent of Gorgas Experimental Station, U. S. Bureau of Mines; and Milton H. Fies, Vice President—Coal Operations, Alabama Power.

"Economic Trends Affecting Transportation of Energy," by S. B. Smith, Ebasco Services, Inc.

"Fuel Availability and Future Power Demand," by Harlan W. Nelson, Battelle Memorial Institute.

"Future Outlook for High Energy Liquid Fuels," by C. C. Miesse, Supervisor, and Paul Lieberman, Associate Research Engineer, Combustion Research Section, Armour Research Foundation.

12:15 p.m. Joint APC—AIEE Luncheon. Sponsored by the American Institute of Electrical Engineers

Chairman: Walter J. Barrett, President, American Institute of Electrical Engineers.

Co-Chairman: E. G. Norell, Chairman, Chicago Section, AIEE.

Speaker: Major General Charles G. Holle, Department of the Army, Office of the Chief of Engineers, Washington.

2:00–3:00 p.m. Central Stations II

Chairman: Johan A. Carlson, Supervisory Engineer, Large Turbine Engineering Dept., Westinghouse Electric Corp.

Co-Chairman: G. F. Markley, Chairman, Power Section, Chicago Section ASME and Sales Engineer, Babcock & Wilcox Co.

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"How to Reduce the Hazard of Inoperative Check Valves, by L. H. Carr, Director of Engineering and Research, Edward Valves Inc.

"The Turbo-Furnace for Multifuel Firing," by C. F. Hawley, Chief Mechanical Engineer, Riley Stoker Corp.

"From Boiler Boil-Out to Operating Date," by J. A. Donald, N. A. Miller, and C. D. Blanke, Sargent & Lundy.

"Vulnerability of a Central Station Power Plant to Attack by a Nuclear Weapon," by David B. Singer, Armour Research Foundation.

2:00–5:00 p.m. Water Technology II—Ion Exchange

Chairman: J. F. Wilkes, Director, Research and Development, Dearborn Chemical Co.

Co-Chairman: L. F. Wirth, Jr., Manager, Ion Exchange Division, National Aluminate Corp.

"High Temperature (475 F) Cation Exchanger Data," by C. F. Paulson, Atomic Power Division, Westinghouse Electric Corp., and C. E. Johnson, National Aluminate Corp.

"Effect of Dissolved Oxygen on Some Performance Characteristics of Weak and Strong Base Anion Exchangers," by Irving B. Abrams, B. N. Dickinsen and M. R. Roberts, Chemical Process Co.

"Comparison of Mixed Bed and Four Bed Demineralizers," by F. B. Wink, Niagara Mohawk Power Corp., and Durando Miller, Permutit Co.

"Demineralizer Treating Hot Lime Zeolite Effluent," by A. K. Sukumar, Ford Motor Co., Dearborn, and S. B. Applebaum, Cochrane Corp.

Friday, March 28, 1958 9:00–12:00 Noon. Gas Turbines

"A Gas Turbine in the Industrial Steam Power Cycle," by J. E. Parker, Union Carbide Chemicals Co.

"How to Integrate Gas Turbines with Other Generation in an Economical Utility Generating System," by W. D. Marsh, General Electric Co.

"Gas Turbines As An Economic Generating Source," by W. H. Ferguson, Westinghouse Electric Corp., and R. E. Strong, Westinghouse Electric Corp.

9:00–10:30 a.m. Water Technology III—Nuclear Power

Chairman: M. D. Baker, Chairman, ASME Joint Research Committee on Boiler Feedwater Studies, and Chief Chemist, West Penn Power Co.

Co-Chairman: Selden Adkins, Manager, Consulting Service, National Aluminate Corp.

"Effect of Local Boiling on Corrosion and Deposition on Reactor Heat Transfer Surfaces," by R. T. Esper and W. E. Hopkins, Jr., Westinghouse Electric Corp., and C. Jacklin and J. H. Phillips, National Aluminate Corp.

"High Flow Rate Demineralization

for Boiling Water Reactors," by H. W. Frazer, Infilco, Inc., A. B. Sisson, Commonwealth Edison Co., and R. C Reid, General Electric Co.,

10:30–12:00 Noon. Nuclear Energy I

Co-Chairman: F. W. McCloska, Partner, Sargent & Lundy, Engineers.

Friday, March 28, 1958 2:00–5:00 p.m. Nuclear Energy II

Chairman: Raymond D. Maxson, Senior Vice President, Commonwealth Edison Co.

Co-Chairman: Darwin Krucoff, Supervisor, Reactor and Nuclear Systems, Physics Research, Armour Research Foundation.

2:00–5:00 p.m.—Industrial Plants

Chairman: Myron B. Golber, Armour & Co.

"Design of Small Industrial Power Plants to Secure Maximum Net Earnings," by Andrew A. Cummins, Cummins & Barnard, Inc.

"New Ideas for Industrial Boiler Plant Coal Handling," by Arthur J. Stock, Stock Equipment Co.

"Short-Cut Methods of Quickly Evaluating Alternate Steam and Power Supplies for Industrial Plants," by W. B. Wilson and D. L. E. Jacobs, General Electric Co.

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..but for long collector life

THE AEROTEC NEW 5 RWS

Aerotec's latest development in the field of erosion resistant dust collector tubes is unique.

Aerotec engineers proved, by accelerated tests under erosive conditions many times greater than normally encountered, that of all metals tested, white cast iron assures maximum resistance to abrasion.

These tests are substantiated by actual installations. They now establish the Aerotec 5 RWS collector with white iron tubes as the ultimate in long life and sustained high efficiency in the field of mechanical collection.

If your dust collection problem requires top mechanical efficiency, discover the assurance of highest performance and long life possible only with an Aerotec 5 RWS. Call or write our Project Engineers today. They are ready to help you solve your dust control problem.

Project Engineers **THE THERMIX CORPORATION** Greenwich, Conn.
(Offices in 38 principal cities)
Canadian Affiliates: T. C. CHOWN, LTD., 164 Metcalfe Ave., Westmount, Montreal 6, Que.

Manufacturers
THE AEROTEC CORPORATION
Greenwich, Conn.

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H-T

Combination Fuel Burner

With Positive Flame Shape Control

For a Steam Output to
150,000 lbs. per hr.
PER BURNER

Recently selected by two prominent U.S. Public Utility Companies to fire steam generators of 1,200,000 and 1,800,000 lbs. per hr. capacity.

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Pay Off Plenty in

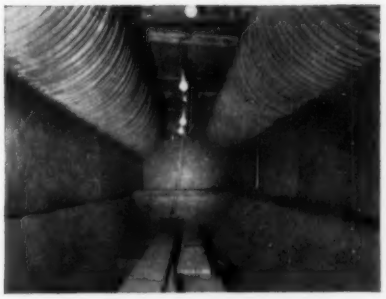
- Longer Service Life
- Lower Maintenance Costs
- Saving Installation Time
- Smaller Inventory of Refractories

R&I, pioneer and a leading producer of castable refractories, offers MOLDIT—the most successful line of hydraulic setting, castable refractory materials for the greatest range of industrial heating applications.

With Moldit—mixed as ordinary concrete—you pour, cast or gun your own refractories in any size and shape, fast. There's no ramming or pounding. No high-cost inventory of special shapes to maintain.

MOLDIT LASTS—outlasts the rest. That's why it is constantly replacing other refractory materials. Moldit air-sets, without prefiring, to full refractory hardness. It's stronger, more resistant to thermal shock and abrasion, impervious to moisture. Plant after plant reports reductions of as much as 90% in repair and maintenance costs when Moldit Castables replace other refractories.

If you have trouble with your present refractory brick, shapes or linings, you can end it with Moldit Castables.



Ashpit of large coal-fired boiler completely "gunned" with R&I Moldit. Records show not a single repair required in 11 years of constant service in a number of ash hoppers lined with Moldit.

Gunning a 5½" thickness of Moldit Chrome Refractory on a boiler floor for maximum resistance to molten slag at 2750° to 2850° F. Such floors have been in service for 6 and 7 years without a failure.

Moldit Castable Refractories

R&I

REFRACTORY CASTABLE AND BONDING CEMENTS

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INSULATING BLOCK, BLANKETS AND CEMENTS

FOR EVERY REQUIREMENT

There are 10 Moldit Refractory and Insulating Refractory Cements to best meet specific thermal, mechanical and chemical corrosion conditions from 2000° to 3000° F.

Send for catalog on Moldit Castables. Also get the story on R&I Super #3000, the truly "wonder" refractory bonding mortar.

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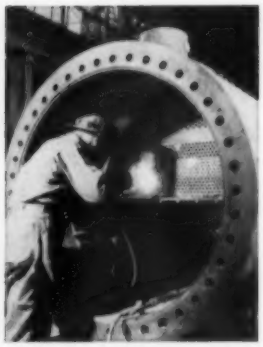
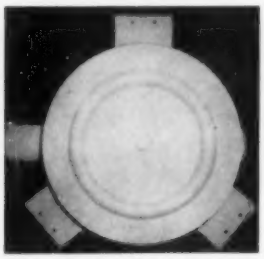
124 Wall Street • New York 5, N. Y.

PROGRESS IN POWER through PROGRESS IN HEAT TRANSFER EQUIPMENT



Workman welding copper-nickel tubes to foot-thick steel tube sheet with 140-monel electrodes. Under destructive testing, rolled joints and tubes welded with cupro nickel rods leaked at elevated pressures, but tubes welded with 140-monel electrodes were leak-proof at 9600 psi.



End view showing torus ring welded to channel and channel cover. Access to head is obtained by cutting ring with special tool; torus ring can be re-used. Conventional split key ring assembly taking the load on the cover is retained.

FIRST ALL-WELDED FEEDWATER HEATERS

▶ A few years ago, an all-welded feedwater heater for 3600 psi and 790F would have been called a fantastic dream.

Yet six all-welded feedwater heaters in this pressure-temperature range are now proving their worth in the Linden, N. J., Generating Station of the Public Service Electric and Gas Company. Designed and manufactured by the Yuba Heat Transfer Division, formerly the Heat Exchanger Division of The Lummus Co., these heaters represent one of the many "firsts" contributed by this organization to the progress of the power industry.

In the heater shown above, two 50-inch-diameter cylinder sections of 1⅛-inch carbon steel were welded together. The open ends of the U-bends are welded, not roller-expanded, into the tube sheet (see upper small photo). Heads are sealed by a steel torus ring welded to channel cover and channel (see lower small photo).

The all-welded design minimizes the leakage which occurs in the conventional bolted and gasketed construction under high temperatures and pressures. Results are reduced maintenance and downtime.

This all-welded construction has been so successful it is certain to be specified for practically all future installations. Yuba engineers would be pleased to work with you. Call on them.

YUBA

CONSOLIDATED INDUSTRIES, INC.

Other Divisions Manufacturing Heat Transfer Equipment
California Steel Products Division, Richmond, Cal.
Adsco Division, Buffalo, N. Y.

YUBA HEAT TRANSFER DIVISION
HONESDALE, PENNSYLVANIA
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STEAM SURFACE CONDENSERS • EVAPORATORS
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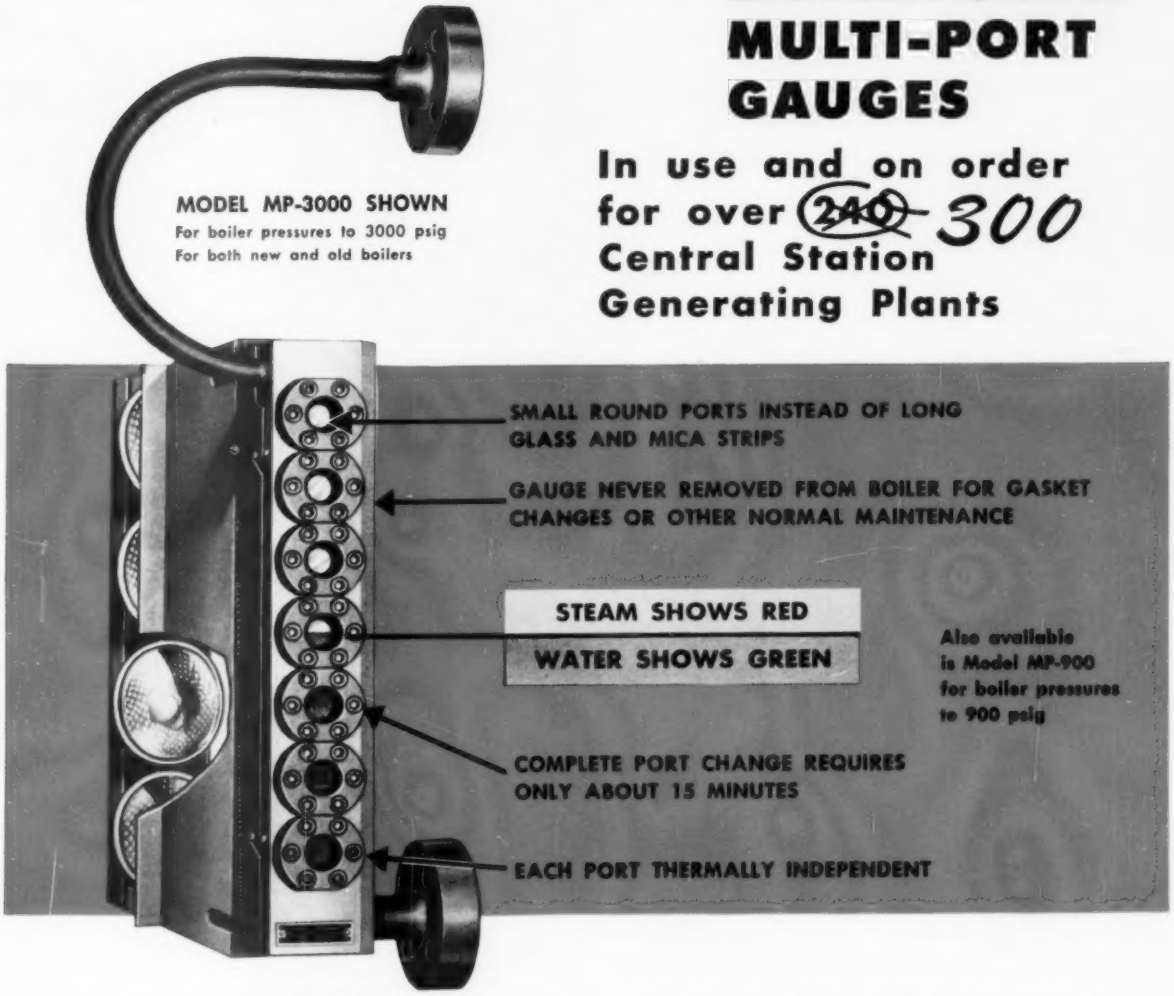
FEEDWATER HEATERS • BAROMETRIC CONDENSERS

MORE THAN ~~950~~ 1400 DIAMOND MULTI-PORT GAUGES


MODEL MP-3000 SHOWN
For boiler pressures to 3000 psig
For both new and old boilers
SMALL ROUND PORTS INSTEAD OF LONG GLASS AND MICA STRIPS
GAUGE NEVER REMOVED FROM BOILER FOR GASKET CHANGES OR OTHER NORMAL MAINTENANCE
STEAM SHOWS RED
WATER SHOWS GREEN
Also available is Model MP-900 for boiler pressures to 900 psig
COMPLETE PORT CHANGE REQUIRES ONLY ABOUT 15 MINUTES
EACH PORT THERMALLY INDEPENDENT

In use and on order for over ~~240~~ 300 Central Station Generating Plants

Because the Diamond Multi-Port solves the problems inherent in water level gauges on boilers operating at high temperatures and pressures, it has had rapid and wide acceptance. In addition to the 1400 for central station generating plants, more than 150 have been sold to industrial power plants.

Advantages of the Multi-Port are many. In addition to those shown above, it has maximum thermal stability for rapid starting . . . "Hi-Lite" illuminator for improved readability . . . welded construction for permanent tightness . . . end stems can be furnished instead of flanges . . . startling reductions in maintenance costs.

Write for Bulletin 1174V (Model MP-3000) or Bulletin 2044V (Model MP-900) for more information.

7801

Diamond

DIAMOND POWER SPECIALTY CORP.

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THIS MAN CAN ADD TO YOUR PROFIT PICTURE. This is a Dowell service engineer—on the job. His knowledge and abilities in chemical cleaning can help you to greater profits. Recently, an eastern corporation used Dowell Service for its boiler cleaning maintenance. Dowell's service engineer studied the problem, did the job. His use of chemical solvents in cleaning tubes and other metal surfaces was effective. On the basis of Dowell Service, this company will realize improved profits of $440,000.

There are three ways you can clean your plant equipment: *Mechanically* with your own crews—inefficient, time consuming and expensive in today's industrial pace. *Chemically* with your own crews—again inefficient and unprofitable because of heavy payroll and the personnel's lack of qualification. Or with *Dowell Service,* the modern chemical cleaning method.

With Dowell Service you receive the benefits of more than fifteen years experience in chemical cleaning—plus special equipment, chemicals, research and trained personnel. You pay one charge, get an efficient job, handled by knowledgeable people.

Every industry can profit from Dowell Service. Ask your maintenance and operating engineers if they have thoroughly investigated the profit possibilities of using Dowell Service. DOWELL INCORPORATED—A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY. Headquarters and research center, Tulsa, Oklahoma; 165 offices and stations to serve you.

Chemical cleaning service for industry DOWELL